PATHOGEN CONTROL COMPOSITIONS AND USES THEREOF

BACKGROUND

Pathogens, including animal pathogens (e.g., bacteria, fungi, parasites, or viruses), cause severe disease in humans and animals. Although a multitude of means have been utilized for attempting to control animal pathogens, or vectors thereof, the demand for safe and effective pathogen control strategies is increasing. Thus, there is need in the art for new methods and compositions to control animal pathogens.

SUMMARY ~~OF THE INVENTION~~

Disclosed herein are pathogen control compositions including a plurality of plant messenger packs that are useful in methods for treating infections in an animal in need thereof, preventing an infection in an animal at risk thereof, or decreasing the fitness of pathogens (e.g., animal pathogens), or vectors thereof.

In one ~~aspect~~example, the disclosure features a pathogen control composition including a plurality of plant messenger packs (PMPs), wherein the composition is formulated for administration to an animal, and wherein the composition includes at least 5% PMPs as measured by wt/vol, percent PMP protein composition, and/or percent lipid composition (e.g., by measuring fluorescently labelled lipids)

In another ~~aspect~~example, the disclosure features a pathogen control composition including a plurality of PMPs, wherein the composition is formulated for delivery to an animal pathogen, and wherein the composition includes at least 5% PMPs.

In still another ~~aspect~~example, the disclosure features a pathogen control composition including a plurality of PMPs, wherein the composition is formulated for delivery to an animal pathogen vector, and wherein the composition includes at least 5% PMPs.

In yet another ~~aspect~~example, the disclosure features a pathogen control composition including a plurality of PMPs, wherein the composition is stable for at least one day at room temperature, and/or stable for at least one week at 4°C.

In some ~~embodiment~~examples of the pathogen control composition, the plurality of PMPs in the composition is at a concentration effective to decrease the fitness of an animal pathogen or an animal pathogen vector. In some ~~embodiment~~examples, the plurality of PMPs in the composition is at a concentration effective to treat an infection in an animal infected with a pathogen. In other ~~embodiment~~examples, the plurality of PMPs in the composition is at a concentration effective to prevent an infection in an animal at risk of an infection with a pathogen.

In another ~~aspect~~example, the disclosure features a pathogen control composition including a plurality of PMPs, wherein the plurality of PMPs in the composition is at a concentration effective to decrease the fitness of an animal pathogen.

In still another ~~aspect~~example, the disclosure features a pathogen control composition including a plurality of PMPs, wherein the plurality of PMPs in the composition is at a concentration effective to decrease the fitness of an animal pathogen vector.

In yet another ~~aspect~~example, the disclosure features a pathogen control composition including a plurality of PMPs, wherein the plurality of PMPs in the composition is at a concentration effective to treat an infection in an animal infected with a pathogen.

And in yet another ~~aspect~~example, the disclosure features a pathogen control composition including a plurality of PMPs, wherein the plurality of PMPs in the composition is at a concentration effective to prevent an infection in an animal at risk of an infection with a pathogen.

In some ~~embodiment~~examples of the pathogen control composition, the plurality of PMPs in the composition is at a concentration of at least 0.01 ng, 0.1 ng, 1 ng, 2 ng, 3 ng, 4 ng, 5 ng, 10 ng, 50 ng, 100 ng, 250 ng, 500 ng, 750 ng, 1 µg, 10 µg, 50 µg, 100 µg, or 250 µg PMP protein/ml. In some ~~embodiment~~examples, the plurality of PMPs further includes an additional pathogen control agent.

In another ~~aspect~~example, the disclosure features a pathogen control composition including a plurality of PMPs, wherein each of the plurality of PMPs includes a heterologous pathogen control agent and wherein the composition is formulated for delivery to an agricultural or veterinary animal pathogen or a vector thereof. In one aspect, the present disclosure refers to a pathogen control composition comprising a plurality of PMPs, wherein each of the plurality of PMPs comprises a heterologous pathogen control agent and wherein the composition is formulated for delivery to an agricultural or veterinary animal pathogen or a vector thereof.

In some ~~embodiment~~examples of the pathogen control composition, the heterologous pathogen control agent is an antibacterial agent, e.g., doxorubicin, an antifungal agent, a virucidal agent, an anti-viral agent, an insecticidal agent, a nematicidal agent, an antiparasitic agent, or an insect repellent. In some ~~embodiment~~examples, the antibacterial agent is an antibiotic, e.g., vancomycin, a penicillin, a cephalosporin, a monobactam, a carbapenem, a macrolide, an aminoglycoside, a quinolone, a sulfonamide, a tetracycline, a glycopeptide, a lipoglycopeptide, an oxazolidinone, a rifamycin, a tuberactinomycin, chloramphenicol, metronidazole, tinidazole, nitrofurantoin, teicoplanin, telavancin, linezolid, cycloserine 2, bacitracin, polymyxin B, viomycin, or capreomycin.

In some ~~embodiment~~examples of the pathogen control composition, the antifungal agent is an allylamine, an imidazole, a triazole, a thiazole, a polyene, or an echinocandin.

In some ~~embodiment~~examples of the pathogen control composition, the insecticidal agent is a chloronicotinyl, a neonicotinoid, a carbamate, an organophosphate, a pyrethroid, an oxadiazine, a spinosyn, a cyclodiene, an organochlorine, a fiprole, a mectin, a diacylhydrazine, a benzoylurea, an organotin, a pyrrole, a dinitroterpenol, a METI, a tetronic acid, a tetramic acid, or a pthalamide.

In some ~~embodiment~~examples of the pathogen control composition, the heterologous pathogen control agent is a small molecule (e.g., an antibiotic or a secondary metabolite), a nucleic acid (e.g., an inhibitory RNA), or a polypeptide.

In some ~~embodiment~~examples of the pathogen control composition, the heterologous pathogen control agent is encapsulated by each of the plurality of PMPs; embedded on the surface of each of the plurality of PMPs; or conjugated to the surface of each of the plurality of PMPs. In some ~~embodiment~~examples, each of the plurality of PMPs further includes an additional pathogen control agent.

In some ~~embodiment~~examples, the pathogen is a bacterium (e.g., a *Pseudomonas* species (e.g., *Pseudomonas aeruginosa*), an *Escherichia* species (e.g., *Escherichia coli*), a *Streptococcus* species, a *Pneumococcus* species, a *Shigella* species, a *Salmonella* species, or a *Campylobacter* species), a fungus (e.g., a *Saccharomyces* species or a *Candida* species), a parasitic insect (e.g., a *Cimex* species), a parasitic nematode (e.g., a *Heligmosomoides* species), or a parasitic protozoan (e.g., a *Trichomonas* species).

In some ~~embodiment~~examples of the pathogen control composition, the vector is a mosquito, a tick, a mite, or a louse.

In some ~~embodiment~~examples of the pathogen control composition, the composition is stable for at least one day at room temperature, and/or stable for at least one week at 4°C; stable for at least 24 hours, 48 hours, seven days, or 30 days at 4°C; or stable at a temperature of at least 20°C, 24°C, or 37°C.

In some ~~embodiment~~examples of the pathogen control composition, the plurality of PMPs in the composition is at a concentration effective to decrease the fitness of an animal pathogen or an animal pathogen vector; effective to treat an infection in an animal infected with a pathogen; or effective to prevent an infection in an animal at risk of an infection with a pathogen.

In some ~~embodiment~~examples, the plurality of PMPs in the composition is at a concentration of at least 0.01 ng, 0.1 ng, 1 ng, 2 ng, 3 ng, 4 ng, 5 ng, 10 ng, 50 ng, 100 ng, 250 ng, 500 ng, 750 ng, 1 µg, 10 µg, 50 µg, 100 µg, or 250 µg PMP protein/mL.

In some ~~embodiment~~examples, the composition includes an agriculturally acceptable carrier or a pharmaceutically acceptable carrier. In some ~~embodiment~~examples, the composition is formulated to stabilize the PMPs. In some ~~embodiment~~examples, the composition is formulated as a liquid, a solid, an aerosol, a paste, a gel, or a gas composition. In some ~~embodiment~~examples, the composition includes at least 5% PMPs.

In another ~~aspect~~example, the disclosure features a pathogen control composition including a plurality of PMPs, wherein the PMPs are isolated from a plant by a process which includes the steps of (a) providing an initial sample from a plant, or a part thereof, wherein the plant or part thereof includes EVs; (b) isolating a crude PMP fraction from the initial sample, wherein the crude PMP fraction has a decreased level of at least one contaminant or undesired component from the plant or part thereof relative to the level in the initial sample; (c) purifying the crude PMP fraction, thereby producing a plurality of pure PMPs, wherein the plurality of pure PMPs have a decreased level of at least one contaminant or undesired component from the plant or part thereof relative to the level in the crude EV fraction; (d) loading the plurality of PMPs of step (c) with a pathogen control agent; and (e) formulating the PMPs of step (d) for delivery to an agricultural or veterinary animal pathogen or a vector thereof. In one aspect, the present disclosure refers to a pathogen control composition comprising a plurality of PMPs, wherein the PMPs are isolated from a plant by a process which comprises the steps of: (a) providing an initial sample from a plant, or a part thereof, wherein the plant or part thereof comprises EVs; (b) isolating a crude PMP fraction from the initial sample, wherein the crude PMP fraction has a decreased level of at least one contaminant or undesired component from the plant or part thereof relative to the level in the initial sample; (c) purifying the crude PMP fraction, thereby producing a plurality of pure PMPs, wherein the plurality of pure PMPs have a decreased level of at least one contaminant or undesired component from the plant or part thereof relative to the level in the crude EV fraction; (d) loading the plurality of PMPs of step (c) with a pathogen control agent; and (e) formulating the PMPs of step (d) for delivery to an agricultural or veterinary animal pathogen or a vector thereof.

In another ~~aspect~~example, the disclosure features an animal pathogen including any one of the pathogen control compositions described herein. In one aspect, the present disclosure refers to an animal pathogen comprising the pathogen control composition as disclosed herein.

In another ~~aspect~~example, the disclosure features an animal pathogen vector including any one of the pathogen control compositions described herein. In one aspect, the present disclosure refers to an animal pathogen vector comprising the pathogen control composition as disclosed herein.

In still another ~~aspect~~example, the disclosure features a method of delivering a pathogen control composition to an animal including administering to the animal any one of the pathogen control compositions described herein. In one aspect, the present disclosure refers to use of the composition as disclosed herein in the manufacture of a medicament for delivering a pathogen control composition to an animal.

In still another ~~aspect~~example, the disclosure features a method of treating an infection in an animal in need thereof, the method including administering to the animal an effective amount of any one of the pathogen control compositions described herein. In one aspect, the present disclosure refers to use of the composition as disclosed herein in the manufacture of a medicament for treating an infection in an animal in need thereof.

In yet another ~~aspect~~example, the disclosure features a method of preventing an infection in an animal at risk thereof, the method including administering to the animal an effective amount of any one of the pathogen control compositions described herein, wherein the method decreases the likelihood of the infection in the animal relative to an untreated animal. In one aspect, the present disclosure refers to use of the composition as disclosed herein in the manufacture of a medicament for preventing an infection in an animal at risk thereof, wherein the use decreases the likelihood of the infection in the animal relative to an untreated animal.

In some ~~embodiment~~examples of the above methods, the infection is caused by a pathogen, and the pathogen is a bacterium (e.g., a *Pseudomonas* species, an *Escherichia* species, a *Streptococcus* species, a *Pneumococcus* species, a *Shigella* species, a *Salmonella* species, or a *Campylobacter* species), a fungus (e.g., a *Saccharomyces* species or a *Candida* species), a virus, a parasitic insect (e.g., a *Cimex* species), a parasitic nematode (e.g., a *Heligmosomoides* species), or a parasitic protozoan (e.g., a *Trichomonas* species).

In some ~~embodiment~~examples, the pathogen control composition is administered to the animal orally, intravenously, or subcutaneously.

In another ~~aspect~~example, the disclosure features a method of delivering a pathogen control composition to a pathogen including contacting the pathogen with any one of the pathogen control compositions described herein. In one aspect, the present disclosure refers to a method of delivering a pathogen control composition to a pathogen comprising contacting the pathogen with the composition as disclosed herein.

In another ~~aspect~~example, the disclosure features a method of decreasing the fitness of a pathogen, the method including delivering to the pathogen any one of the pathogen control compositions described herein, wherein the method decreases the fitness of the pathogen relative to an untreated pathogen. In one aspect, the present disclosure refers to a method of decreasing the fitness of a pathogen, the method comprising delivering to the pathogen the composition as disclosed herein, wherein the method decreases the fitness of the pathogen relative to an untreated pathogen.

In some ~~embodiment~~examples, the method includes delivering the composition to at least one habitat where the pathogen grows, lives, reproduces, feeds, or infests. In some ~~embodiment~~examples, the composition is delivered as a pathogen comestible composition for ingestion by the pathogen.

In some ~~embodiment~~examples of the above methods, the pathogen is a bacterium (e.g., a *Pseudomonas* species, an *Escherichia* species, a *Streptococcus* species, a *Pneumococcus* species, a *Shigella* species, a *Salmonella* species, or a *Campylobacter* species), a fungus (e.g., a *Saccharomyces* species or a *Candida* species), a parasitic insect (e.g., a *Cimex* species), a parasitic nematode (e.g., a *Heligmosomoides* species), or a parasitic protozoan (e.g., a *Trichomonas* species).

In some ~~embodiment~~examples, the composition is delivered as a liquid, a solid, an aerosol, a paste, a gel, or a gas.

In another ~~aspect~~example, the disclosure features a method of decreasing the fitness of an animal pathogen vector, the method including delivering to the vector an effective amount of any one of the pathogen control compositions described herein, wherein the method decreases the fitness of the vector relative to an untreated vector. In one aspect, the present disclosure refers to a method of decreasing the fitness of an animal pathogen vector, the method comprising delivering to the vector an effective amount of the composition as disclosed herein, wherein the method decreases the fitness of the vector relative to an untreated vector.

In some ~~embodiment~~examples, the method includes delivering the composition to at least one habitat where the vector grows, lives, reproduces, feeds, or infests. In some ~~embodiment~~examples, the composition is delivered as a comestible composition for ingestion by the vector. In some ~~embodiment~~examples, the vector is an insect, e.g., a mosquito, a tick, a mite, or a louse. In some ~~embodiment~~examples, the composition is delivered as a liquid, a solid, an aerosol, a paste, a gel, or a gas.

In another ~~aspect~~example, the disclosure features a method of treating an animal having a fungal infection, wherein the method includes administering to the animal an effective amount of a pathogen control composition including a plurality of PMPs. In one aspect, the present disclosure refers to use of a pathogen control composition comprising a plurality of PMPs in the manufacture of a medicament for treating an animal having a fungal infection.

In another ~~aspect~~example, the disclosure features a method of treating an animal having a fungal infection, wherein the method includes administering to the animal an effective amount of a pathogen control composition including a plurality of PMPs, and wherein the plurality of PMPs includes an antifungal agent. In one aspect, the present disclosure refers to use of a pathogen control composition comprising a plurality of PMPs in the manufacture of a medicament for treating an animal having a fungal infection, wherein the plurality of PMPs comprises an antifungal agent.

In some ~~embodiment~~examples, the antifungal agent is a nucleic acid that inhibits expression of a gene in a fungus that causes the fungal infection. In some ~~embodiment~~examples, the gene is Enhanced Filamentous Growth Protein (EFG1). In some ~~embodiment~~examples, the fungal infection is caused by *Candida albicans*.

In some ~~embodiment~~examples, the composition includes a PMP derived from Arabidopsis.

In some ~~embodiment~~examples, the method decreases or substantially eliminates the fungal infection.

In another ~~aspect~~example, the disclosure features a method of treating an animal having a bacterial infection, wherein the method includes administering to the animal an effective amount of a pathogen control composition including a plurality of PMPs. In one aspect, the present disclosure refers to use of a pathogen control composition comprising a plurality of PMPs in the manufacture of a medicament for treating an animal having a bacterial infection.

In another ~~aspect~~example, the disclosure features a method of treating an animal having a bacterial infection, wherein the method includes administering to the animal an effective amount of a pathogen control composition including a plurality of PMPs, and wherein the plurality of PMPs includes an antibacterial agent. In one aspect, the present disclosure refers to use of a pathogen control composition comprising a plurality of PMPs in the manufacture of a medicament for treating an animal having a bacterial infection, wherein the plurality of PMPs comprises an antibacterial agent.

In some ~~embodiment~~examples, the antibacterial agent is Amphotericin B.

In some ~~embodiment~~examples, the bacterium is a *Pseudomonas* species, an *Escherichia* species, a *Streptococcus* species, a *Pneumococcus* species, a *Shigella* species, a *Salmonella* species, or a *Campylobacter* species.

In some ~~embodiment~~examples, the composition includes a PMP derived from Arabidopsis.

In some ~~embodiment~~examples, the method decreases or substantially eliminates the bacterial infection.

In some ~~embodiment~~examples, the animal is a veterinary animal, or a livestock animal.

In another ~~aspect~~example, the disclosure features a method of decreasing the fitness of a parasitic insect, wherein the method includes delivering to the parasitic insect a pathogen control composition including a plurality of PMPs. In one aspect, the present disclosure refers to a method of decreasing the fitness of a parasitic insect, wherein the method comprises delivering to the parasitic insect a pathogen control composition comprising a plurality of PMPs.

In another ~~aspect~~example, the disclosure features a method of decreasing the fitness of a parasitic insect, wherein the method includes delivering to the parasitic insect a pathogen control composition including a plurality of PMPs, and wherein the plurality of PMPs include an insecticidal agent. In one aspect, the present disclosure refers to a method of decreasing the fitness of a parasitic insect, wherein the method comprises delivering to the parasitic insect a pathogen control composition comprising a plurality of PMPs, and wherein the plurality of PMPs comprise an insecticidal agent.

In some ~~embodiment~~examples, the insecticidal agent is a peptide nucleic acid.

In some ~~embodiment~~examples, the parasitic insect is a bedbug.

In some ~~embodiment~~examples, the method decreases the fitness of the parasitic insect relative to an untreated parasitic insect.

In another ~~aspect~~example, the disclosure features a method of decreasing the fitness of a parasitic nematode, wherein the method includes delivering to the parasitic nematode a pathogen control composition including a plurality of PMPs. In one aspect, the present disclosure refers to a method of decreasing the fitness of a parasitic nematode, wherein the method comprises delivering to the parasitic nematode a pathogen control composition comprising a plurality of PMPs.

In another ~~aspect~~example, the disclosure features a method of decreasing the fitness of a parasitic nematode, wherein the method includes delivering to the parasitic nematode a pathogen control composition including a plurality of PMPs, and wherein the plurality of PMPs includes a nematicidal agent. In one aspect, the present disclosure refers to a method of decreasing the fitness of a parasitic nematode, wherein the method comprises delivering to the parasitic nematode a pathogen control composition comprising a plurality of PMPs, and wherein the plurality of PMPs comprises a nematicidal agent.

In some ~~embodiment~~examples, the parasitic nematode is *Heligmosomoides polygyrus*.

In some ~~embodiment~~examples, the method decreases the fitness of the parasitic nematode relative to an untreated parasitic nematode.

In another ~~aspect~~example, the disclosure features a method of decreasing the fitness of a parasitic protozoan, wherein the method includes delivering to the parasitic protozoan a pathogen control composition including a plurality of PMPs. In one aspect, the present disclosure refers to a method of decreasing the fitness of a parasitic protozoan, wherein the method comprises delivering to the parasitic protozoan a pathogen control composition comprising a plurality of PMPs.

In another ~~aspect~~example, the disclosure features a method of decreasing the fitness of a parasitic protozoan, wherein the method includes delivering to the parasitic protozoan a pathogen control composition including a plurality of PMPs, and wherein the plurality of PMPs includes an antiparasitic agent. In one aspect, the present disclosure refers to a method of decreasing the fitness of a parasitic protozoan, wherein the method comprises delivering to the parasitic protozoan a pathogen control composition comprising a plurality of PMPs, and wherein the plurality of PMPs comprises an antiparasitic agent.

In some ~~embodiment~~example**s**, the parasitic protozoan is *T. vaginalis*.

In some ~~embodiment~~example**s**, the method decreases the fitness of the parasitic protozoan relative to an untreated parasitic protozoan.

In another ~~aspect~~example, the disclosure features a method of decreasing the fitness of an insect vector of an animal pathogen, wherein the method includes delivering to the vector a pathogen control composition including a plurality of PMPs. In one aspect, the present disclosure refers to a method of decreasing the fitness of an insect vector of an animal pathogen, wherein the method comprises delivering to the vector a pathogen control composition comprising a plurality of PMPs.

In another ~~aspect~~example, the disclosure features a method of decreasing the fitness of an insect vector of an animal pathogen, wherein the method includes delivering to the vector a pathogen control composition including a plurality of PMPs, and wherein the plurality of PMPs includes an insecticidal agent. In one aspect, the present disclosure refers to a method of decreasing the fitness of an insect vector of an animal pathogen, wherein the method comprises delivering to the vector a pathogen control composition comprising a plurality of PMPs, and wherein the plurality of PMPs comprises an insecticidal agent.

In some ~~embodiment~~example**s**, the method decreases the fitness of the vector relative to an untreated vector.

In some ~~embodiment~~example**s**, the insect is a mosquito, tick, mite, or louse.

Other features and advantages of the ~~invention~~disclosure will be apparent from the following Detailed Description and the Claims.

Definitions

As used herein, the term “animal” refers to humans, livestock, farm animals, or mammalian veterinary animals (e.g., including for example, dogs, cats, horses, rabbits, zoo animals, cows, pigs, sheep, chickens, and non-human primates).

As used herein “decreasing the fitness of a pathogen” refers to any disruption to pathogen physiology as a consequence of administration of a pathogen control composition described herein, including, but not limited to, any one or more of the following desired effects: (1) decreasing a population of a pathogen by about 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, 95%, 99%, 100% or more; (2) decreasing the reproductive rate of a pathogen by about 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, 95%, 99%, 100% or more; (3) decreasing the mobility of a pathogen by about 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, 95%, 99%, 100% or more; (4) decreasing the body weight or mass of a pathogen by about 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, 95%, 99%, 100% or more; (5) decreasing the metabolic rate or activity of a pathogen by about 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, 95%, 99%, 100% or more; or (6) decreasing pathogen transmission (e.g., vertical or horizontal transmission of a pathogen from one insect to another) by a pathogen by about 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, 95%, 99%, 100% or more. A decrease in pathogen fitness can be determined, e.g., in comparison to an untreated pathogen.

What is claimed is:

Claims

1. A pathogen control composition comprising a plurality of PMPs, wherein each of the plurality of PMPs comprises a heterologous pathogen control agent and wherein the composition is formulated for delivery to an agricultural or veterinary animal pathogen or a vector thereof.

2. The pathogen control composition of claim 1, wherein the heterologous pathogen control agent is an antibacterial agent, an antifungal agent, a virucidal agent, an anti-viral agent, an insecticidal agent, a nematicidal agent, an antiparasitic agent, or an insect repellent.

3. The pathogen control composition of claim 2, wherein the antibacterial agent is doxorubicin.

4. The pathogen control composition of claim 2, wherein the antibacterial agent is an antibiotic.

5. The pathogen control composition of claim 4, wherein the antibiotic is vancomycin.

6. The pathogen control composition of claim 4, wherein the antibiotic is a penicillin, a cephalosporin, a monobactam, a carbapenem, a macrolide, an aminoglycoside, a quinolone, a sulfonamide, a tetracycline, a glycopeptide, a lipoglycopeptide, an oxazolidinone, a rifamycin, a tuberactinomycin, chloramphenicol, metronidazole, tinidazole, nitrofurantoin, teicoplanin, telavancin, linezolid, cycloserine 2, bacitracin, polymyxin B, viomycin, or capreomycin.

7. The pathogen control composition of claim 2, wherein the antifungal agent is an allylamine, an imidazole, a triazole, a thiazole, a polyene, or an echinocandin.

8. The pathogen control composition of claim 2, wherein the insecticidal agent is a chloronicotinyl, a neonicotinoid, a carbamate, an organophosphate, a pyrethroid, an oxadiazine, a spinosyn, a cyclodiene, an organochlorine, a fiprole, a mectin, a diacylhydrazine, a benzoylurea, an organotin, a pyrrole, a dinitroterpenol, a METI, a tetronic acid, a tetramic acid, or a pthalamide.

9. The pathogen control composition of claim 1, wherein the heterologous pathogen control agent is a small molecule, a nucleic acid, or a polypeptide.

10. The pathogen control composition of claim 9, wherein the small molecule is an antibiotic or a secondary metabolite.

11. The pathogen control composition of claim 9, wherein the nucleic acid is an inhibitory RNA.

12. The pathogen control composition of claim 1, wherein the heterologous pathogen control agent is encapsulated by each of the plurality of PMPs.

13. The pathogen control composition of claim 1, wherein the heterologous pathogen control agent is embedded on the surface of each of the plurality of PMPs.

14. The pathogen control composition of claim 1, wherein the heterologous pathogen control agent is conjugated to the surface of each of the plurality of PMPs.

15. The pathogen control composition of claim 1, wherein each of the plurality of PMPs further comprises an additional pathogen control agent.

16. The pathogen control composition of claim 1, wherein the pathogen is a bacterium, a fungus, a parasitic insect, a parasitic nematode, or a parasitic protozoan.

17. The pathogen control composition of claim 16, wherein the bacterium is a *Pseudomonas* species, an *Escherichia* species, a *Streptococcus* species, a *Pneumococcus* species, a *Shigella* species, a *Salmonella* species, or a *Campylobacter* species.

18. The pathogen control composition of claim 17, wherein the *Pseudomonas* species is *Pseudomonas aeruginosa.*

19. The pathogen control composition of claim 17, wherein the *Escherichia* species is *Escherichia coli.*

20. The pathogen control composition of claim 16, wherein the fungus is a *Saccharomyces* species or a *Candida* species.

21. The pathogen control composition of claim 16, wherein the parasitic insect is a *Cimex* species.

22. The pathogen control composition of claim 16, wherein the parasitic nematode is a *Heligmosomoides* species.

23. The pathogen control composition of claim 16, wherein the parasitic protozoan is a *Trichomonas* species.

24. The pathogen control composition of claim 1, wherein the vector is an insect.

25. The pathogen control composition of claim 24, wherein the vector is a mosquito, a tick, a mite, or a louse.

26. The pathogen control composition of claim 1, wherein the composition is stable for at least one day at room temperature, and/or stable for at least one week at 4°C.

27. The pathogen control composition of claim 1, wherein the PMPs are stable for at least 24 hours, 48 hours, seven days, or 30 days at 4°C.

28. The pathogen control composition of claim 27, wherein the PMPs are stable at a temperature of at least 20°C, 24°C, or 37°C.

29. The pathogen control composition of claim 1, wherein the plurality of PMPs in the composition is at a concentration effective to decrease the fitness of an animal pathogen.

30. The pathogen control composition of claim 1, wherein the plurality of PMPs in the composition is at a concentration effective to decrease the fitness of an animal pathogen vector.

31. The pathogen control composition of claim 1, wherein the plurality of PMPs in the composition is at a concentration effective to treat an infection in an animal infected with a pathogen.

32. The pathogen control composition of claim 1, wherein the plurality of PMPs in the composition is at a concentration effective to prevent an infection in an animal at risk of an infection with a pathogen.

33. The pathogen control composition of claim 1, wherein the plurality of PMPs in the composition is at a concentration of 0.01 ng, 0.1 ng, 1 ng, 2 ng, 3 ng, 4 ng, 5 ng, 10 ng, 50 ng, 100 ng, 250 ng, 500 ng, 750 ng, 1 µg, 10 µg, 50 µg, 100 µg, or 250 µg PMP protein/ml.

34. The pathogen control composition of claim 1, wherein the composition comprises an agriculturally acceptable carrier.

35. The pathogen control composition of claim 1, wherein the composition comprises a pharmaceutically acceptable carrier.

36. The pathogen control composition of claim 1, wherein the composition is formulated to stabilize the PMPs.

37. The pathogen control composition of claim 1, wherein the composition is formulated as a liquid, a solid, an aerosol, a paste, a gel, or a gas composition.

38. The pathogen control composition of claim 1, wherein the composition comprises at least 5% PMPs.

39. A pathogen control composition comprising a plurality of PMPs, wherein the PMPs are isolated from a plant by a process which comprises the steps of:

(a) providing an initial sample from a plant, or a part thereof, wherein the plant or part thereof comprises EVs;

(b) isolating a crude PMP fraction from the initial sample, wherein the crude PMP fraction has a decreased level of at least one contaminant or undesired component from the plant or part thereof relative to the level in the initial sample;

(c) purifying the crude PMP fraction, thereby producing a plurality of pure PMPs, wherein the plurality of pure PMPs have a decreased level of at least one contaminant or undesired component from the plant or part thereof relative to the level in the crude EV fraction;

(d) loading the plurality of PMPs of step (c) with a pathogen control agent; and

(e) formulating the PMPs of step (d) for delivery to an agricultural or veterinary animal pathogen or a vector thereof.

40. An animal pathogen comprising the pathogen control composition of claim 1.

41. An animal pathogen vector comprising the pathogen control composition of claim 1.

42. ~~A method of delivering a pathogen control composition to an animal comprising administering to the animal~~ Use of the composition of claim 1 in the manufacture of a medicament for delivering a pathogen control composition to an animal.

43. ~~A method of treating an infection in an animal in need thereof, the method comprising administering to the animal an effective amount of~~ Use of the composition of claim 1 in the manufacture of a medicament for treating an infection in an animal in need thereof.

44. ~~A method of preventing an infection in an animal at risk thereof, the method comprising administering to the animal an effective amount of~~ Use of the composition of claim 1 in the manufacture of a medicament for preventing an infection in an animal at risk thereof, wherein the use~~method~~ decreases the likelihood of the infection in the animal relative to an untreated animal.

45. The use~~method~~ of claim 42, wherein the infection is caused by a pathogen, and the pathogen is a bacterium, a fungus, a virus, a parasitic insect, a parasitic nematode, or a parasitic protozoan.

46. The use~~method~~ of claim 45, wherein the bacterium is a *Pseudomonas* species, an *Escherichia* species, a *Streptococcus* species, a *Pneumococcus* species, a *Shigella* species, a *Salmonella* species, or a *Campylobacter* species.

47. The use~~method~~ of claim 45, wherein the fungus is a *Saccharomyces* species or a *Candida* species.

48. The use~~method~~ of claim 45, wherein the parasitic insect is a *Cimex* species.

49. The use~~method~~ of claim 45, wherein the parasitic nematode is a *Heligmosomoides* species.

50. The use~~method~~ of claim 45, wherein the parasitic protozoan is a *Trichomonas* species.

51. The use~~method~~ of claim 42, wherein the pathogen control composition is to be administered to the animal orally, intravenously, or subcutaneously.

52. A method of delivering a pathogen control composition to a pathogen comprising contacting the pathogen with the composition of claim 1.

53. A method of decreasing the fitness of a pathogen, the method comprising delivering to the pathogen the composition of claim 1, wherein the method decreases the fitness of the pathogen relative to an untreated pathogen.

54. The method of claim 52, wherein the method comprises delivering the composition to at least one habitat where the pathogen grows, lives, reproduces, feeds, or infests.

55. The method of claim 52, wherein the composition is delivered as a pathogen comestible composition for ingestion by the pathogen.

56. The method of claim 52, wherein the pathogen is a bacterium, a fungus, a parasitic insect, a parasitic nematode, or a parasitic protozoan.

57. The method of claim 56, wherein the bacterium is a *Pseudomonas* species, an *Escherichia* species, a *Streptococcus* species, a *Pneumococcus* species, a *Shigella* species, a *Salmonella* species, or a *Campylobacter* species.

58. The method of claim 56, wherein the fungus is a *Saccharomyces* species or a *Candida* species.

59. The method of claim 56, wherein the parasitic insect is a *Cimex* species.

60. The method of claim 56, wherein the parasitic nematode is a *Heligmosomoides* species.

61. The method of claim 56, wherein the parasitic protozoan is a *Trichomonas* species.

62. The method of claim 52, wherein the composition is delivered as a liquid, a solid, an aerosol, a paste, a gel, or a gas.

63. A method of decreasing the fitness of an animal pathogen vector, the method comprising delivering to the vector an effective amount of the composition of claim 1, wherein the method decreases the fitness of the vector relative to an untreated vector.

64. The method of claim 63, wherein the method comprises delivering the composition to at least one habitat where the vector grows, lives, reproduces, feeds, or infests.

65. The method of claim 63, wherein the composition is delivered as a comestible composition for ingestion by the vector.

66. The method of claim 63, wherein the vector is an insect.

67. The method of claim 66, wherein the insect is a mosquito, a tick, a mite, or a louse.

68. The method of claim 63, wherein the composition is delivered as a liquid, a solid, an aerosol, a paste, a gel, or a gas.

69. ~~A method of treating an animal having a fungal infection, wherein the method comprises administering to the animal an effective amount~~ Use of a pathogen control composition comprising a plurality of PMPs in the manufacture of a medicament for treating an animal having a fungal infection.

70. ~~A method of treating an animal having a fungal infection, wherein the method comprises administering to the animal an effective amount~~ Use of a pathogen control composition comprising a plurality of PMPs in the manufacture of a medicament for treating an animal having a fungal infection, ~~and~~ wherein the plurality of PMPs comprises an antifungal agent.

71. The use~~method~~ of claim 70, wherein the antifungal agent is a nucleic acid that inhibits expression of a gene in a fungus that causes the fungal infection.

72. The use~~method~~ of claim 71, wherein the gene is Enhanced Filamentous Growth Protein (EFG1).

73. The use~~method~~ of claim 70, wherein the fungal infection is caused by *Candida albicans*.

74. The use~~method~~ of claim 70, wherein the composition comprises a PMP derived from Arabidopsis.

75. The use~~method~~ of claim 70, wherein the use~~method~~ decreases or substantially eliminates the fungal infection.

76. ~~A method of treating an animal having a bacterial infection, wherein the method comprises administering to the animal an effective amount~~ Use of a pathogen control composition comprising a plurality of PMPs in the manufacture of a medicament for treating an animal having a bacterial infection.

77. ~~A method of treating an animal having a bacterial infection, wherein the method comprises administering to the animal an effective amount~~ Use of a pathogen control composition comprising a plurality of PMPs in the manufacture of a medicament for treating an animal having a bacterial infection, ~~and~~ wherein the plurality of PMPs comprises an antibacterial agent.

78. The use~~method~~ of claim 77, wherein the antibacterial agent is Amphotericin B.

79. The use~~method~~ of claim 77, wherein the bacterium is a *Pseudomonas* species, an *Escherichia* species, a *Streptococcus* species, a *Pneumococcus* species, a *Shigella* species, a *Salmonella* species, or a *Campylobacter* species.

80. The use~~method~~ of claim 77, wherein the composition comprises a PMP derived from Arabidopsis.

81. The use~~method~~ of claim 77, wherein the use~~method~~ decreases or substantially eliminates the bacterial infection.

82. The use~~method~~ of claim 69, wherein the animal is a veterinary animal, or a livestock animal.

83. A method of decreasing the fitness of a parasitic insect, wherein the method comprises delivering to the parasitic insect a pathogen control composition comprising a plurality of PMPs.

84. A method of decreasing the fitness of a parasitic insect, wherein the method comprises delivering to the parasitic insect a pathogen control composition comprising a plurality of PMPs, and wherein the plurality of PMPs comprise an insecticidal agent.

85. The method of claim 84, wherein the insecticidal agent is a peptide nucleic acid.

86. The method of claim 83, wherein the parasitic insect is a bedbug.

87. The method of claim 83, wherein the method decreases the fitness of the parasitic insect relative to an untreated parasitic insect.

88. A method of decreasing the fitness of a parasitic nematode, wherein the method comprises delivering to the parasitic nematode a pathogen control composition comprising a plurality of PMPs.

89. A method of decreasing the fitness of a parasitic nematode, wherein the method comprises delivering to the parasitic nematode a pathogen control composition comprising a plurality of PMPs, and wherein the plurality of PMPs comprises a nematicidal agent.

90. The method of claim 88, wherein the parasitic nematode is *Heligmosomoides polygyrus*.

91. The method of claim 88, wherein the method decreases the fitness of the parasitic nematode relative to an untreated parasitic nematode.

92. A method of decreasing the fitness of a parasitic protozoan, wherein the method comprises delivering to the parasitic protozoan a pathogen control composition comprising a plurality of PMPs.

93. A method of decreasing the fitness of a parasitic protozoan, wherein the method comprises delivering to the parasitic protozoan a pathogen control composition comprising a plurality of PMPs, and wherein the plurality of PMPs comprises an antiparasitic agent.

94. The method of claim 92, wherein the parasitic protozoan is *T. vaginalis*.

95. The method of claim 92, wherein the method decreases the fitness of the parasitic protozoan relative to an untreated parasitic protozoan.

96. A method of decreasing the fitness of an insect vector of an animal pathogen, wherein the method comprises delivering to the vector a pathogen control composition comprising a plurality of PMPs.

97. A method of decreasing the fitness of an insect vector of an animal pathogen, wherein the method comprises delivering to the vector a pathogen control composition comprising a plurality of PMPs, and wherein the plurality of PMPs comprises an insecticidal agent.

98. The method of claim 96, wherein the method decreases the fitness of the vector relative to an untreated vector.

99. The method of claim 96, wherein the insect is a mosquito, tick, mite, or louse.