

Grasshopper Mortality: Pathogens, Parasites, and Predators

Grasshopper population numbers are a balance between fecundity and mortality. Mortality of grasshoppers by natural enemies; pathogens, parasites, and predators is high. Grasshoppers have numerous natural enemies. Most grasshopper species have high fecundity levels and can replace themselves several times over. Most female grasshoppers that survive to the adult stage typically produce 100 to 200 fertile eggs. Without the activities of the natural enemies, grasshoppers would be a perpetual serious annual problem.

The incidence of parasites and predators tends to increase proportionally with the increase in grasshopper densities. The increased mortality rate from natural enemies would be expected to cause reductions in the longevity of individual grasshoppers that are members of populations with greater densities (Hewitt and Onsager 1983). Even though the complex of natural enemies can cause high mortality rates in grasshopper populations, none of the individual natural enemies are technically biological control agents. None of the natural enemies are known to reduce the grasshopper populations severe enough to prevent periodic outbreaks.

Grasshopper species have affinities to several grassland biomes resulting in diverse combinations of grasshopper assemblages in different habitats. Grasshopper natural enemies also have affinities to several grassland biomes that results in the development of different combinations of pathogens, parasites, and predators in the various grassland habitats. The combinations of grasshopper species present vs. the combination of natural enemies present will be extremely variable in the numerous different grassland habitats.

Pathogens

Pathogens are microorganisms that cause diseases. It is uncommon for grasshoppers to be affected by diseases caused by viruses and bacteria. Two types of viruses have been isolated from grasshoppers; entomopoxvirus and crystalline array viruses (Hostetter and Streett 1994) (table 1). As of yet, no bacteria have been found to effectively increase mortality of grasshoppers under field conditions (Hostetter and Streett 1994). Understanding the roles of viruses and bacteria causing grasshopper mortality is still at rudimentary stages.

Protozoa are unicellular microorganisms. Only one genus, *Nosema*, is known to affect at least 90 species of grasshoppers. Three species of *Nosema* have been isolated: *N. locustae*, *N. acridophagus*, and *N. cuneatum* (table 1). Grasshoppers are infected with *Nosema* by consuming the spore stage on food items or by eating infected cadavers. The ingested spores enter the epithelial cells of the midgut, reproduce asexually, and then attack the fat bodies, and the pericardial and neural tissue of the host. Some grasshopper species can overcome the protozoan disease by encapsulating the mobile sporozoan. Infection levels can be acute, causing death in several days, and can be chronic, showing no outward symptoms. Microsporidia are passed to the next generation through eggs laid by infected females (Watts et al. 1989, Streett 1994, Hildreth et al. 1994, Vaughn et al. 1994, Hostetter and Streett 1994).

A few fungi infect grasshoppers. Fungi spores are not infectious when ingested by grasshoppers. Fungi spores that come in contact with the exoskeleton of a grasshopper, attach with external mycelial on the surface of the grasshopper, and then develops a tube that penetrates the body wall releasing a protoplast which has a single nucleus capable of asexual reproduction in the body cavity of the host. The fungus grows rapidly inside of the host, killing the grasshopper. The fungus grows back through the body wall, forms vegetative stalks that produce primary spores, conidia, that are discharged into the atmosphere capable of infecting some of the grasshopper species it comes in contact (Watts et al. 1989, Hostetter and Streett 1994, Bidochka and Roberts 1994).

There are two groups of fungi that are pathogenic to grasshoppers. The deuteromycota fungi are facultative and do not require a grasshopper host to live. An infection of *Beauveria bassiana* is characterized by white mycelial and the conidia are globose, globelike. An infection of *Metarhizium anisopliae* is characterized by green mycelial and the conidia are rod shaped. An infection of *Aspergillus flavus* is characterized by green mycelial and the conidia are spherical (Bidochka and Roberts 1994) (table 1).

The zygomycota fungi are obligate and require a grasshopper host to live. The pathogenic fungi are a complex of *Entomophaga grylli* comprised of pathotypes which have recently been separated into species. *Entomophaga maclead* (pathotype I) infect bandwinged grasshoppers of the

Oedipodinae subfamily. *Entomophaga calopteni* (pathotype II) infect spurthroated grasshoppers of the Melanoplinae subfamily. *Entomophaga praxibuli* (pathotype III) infect slantfaced grasshoppers of the Gomphocerinae subfamily, spurthroated grasshoppers of the Melanoplinae subfamily, and bandwinged grasshoppers of the Oedipodinae subfamily (Hostetter and Streett 1994, Bidochka and Roberts 1994) (table 1). Epizootic infections of fungal diseases require high relative humidity associated with microhabitats in relatively tall dense vegetation. *Entomophaga* decreases or ceases to exist in dry habitats. In humid environments, the highest mortality rate usually occurs before the nymphs complete the third instar. During the advanced stages of infection from *Entomophaga* pathotypes, the infected grasshoppers crawl to the tops of plants, wrap their legs around the plant stalk, and die with head up (Bidochka and Roberts 1994).

Invertebrate Parasites and Predators

Numerous insects, arachinids, and nematodes are parasites on or in grasshoppers or predators of grasshoppers. Not all of the listed parasites and predators occur on all rangeland ecosystems, however, more than one natural enemy would be expected to be active at some level on all grasshopper habitats. The invertebrate natural enemies of grasshoppers are considered to be nontarget species but are susceptible to the chemical insecticides used to control grasshopper infestations.

The larvae of 26 species of blister beetles (Meloidae) consume and destroy grasshopper egg pods. The female blister beetle lays 100 to 200 eggs in a chamber she has dug into the soil. After hatching, the larvae are quite mobile and search for food in the soil. When they find a grasshopper egg pod, they feed on the eggs, and transform into a fat white grub. Completion of larvae development may require more than one grasshopper egg pod (Munro 1939, Dysart 1994) (table 1).

The larvae of numerous species of ground beetles (Carabidae) consume and destroy grasshopper egg pods (Dysart 1994) (table 1).

The larvae of an anthomyiid fly (Anthomyiidae) are endoparasites of nymph and adult grasshoppers. The gravid female fly captures a grasshopper, chews a hole in the grasshopper exoskeleton with her rasping mouth parts, and feeds upon the body fluids of the host, then she inserts her ovipositor through the hole and lays eggs inside the host body cavity. The eggs hatch within 48 hours.

Twenty to seventy larvae feed on the host and complete 3 instars in 16 to 20 days. Mature larvae emerge from the host, enter the soil, and pupate. The process reduces grasshopper feeding, prevents reproduction, and with larvae emergence, kills the host grasshopper (Watts et al. 1989, Hostetter 1994) (table 1).

The adults of 26 species of robber flies (Asilidae) are large enough to capture nymph and adult grasshoppers. The robber fly sucks out the internal contents and leaves an empty grasshopper shell. Under some conditions, robber flies can reduce grasshopper populations by 11% to 15% (Watts et al. 1989, Hostetter 1994) (table 1).

The larvae of 13 genera of bee flies (Bombyliidae) are predators of grasshopper egg pods. Bee fly eggs are deposited in soil cracks near ovipositing grasshoppers. The bee fly eggs hatch after a brief incubation period and the larvae wander through the soil in search for food, randomly locating the nearby egg pods. Bee fly larvae consume and destroy one to three egg pods to complete development. The fully developed larvae moves near the soil surface and pupates (Munro 1939, Dysart 1994) (table 1).

The larvae of 2 species of tangleveined flies (Nemestrinidae) are endoparasites of late instar nymphs and adult grasshoppers. The tangleveined flies overwinter in the soil as mature larvae, pupate and emerge as adults in the spring. Gravid female flies deposit thousands of eggs on dead vegetation or fenceposts at heights of 3 to 40 feet above the ground. The eggs hatch in 8 to 10 days and the small larva are distributed by the wind. The fly larva makes random contact with a grasshopper host and penetrates the body wall within 30 minutes. The larva develops a spiral respiratory tube that opens to the outside of the host's body wall. The larva feeds on the host's fat and reproductive tissue, completing 4 instars. The large larva emerges, then burrows into the soil. The process reduces grasshopper feeding, prevents reproduction, and with larva emergence, kills the host grasshopper (Watts et al. 1989, Hostetter 1994) (table 1).

The larvae of 21 to 23 species of flesh flies (Sarcophagidae) are endoparasites of nymph and adult grasshoppers. Flesh flies are ovoviviparous, the eggs develop and hatch in the female fly uterus. The female fly captures a grasshopper in the air or on the ground and deposits live larvae in or on the host. The larvae deposited on a grasshopper quickly penetrates the host body wall.

The fly larvae feed on the hosts body fluids and tissue, and continue feeding through the completion of 3 instars in 6 to 9 days. The mature larva exits the host and pupates in the soil. The process reduces grasshopper feeding, prevents reproduction, and with larva emergence, kills the host grasshopper (Watts et al. 1989, Hostetter 1994) (table 1).

The larvae of 3 species of tachinid flies (Tachinidae) are endoparasites of nymph and adult grasshoppers. The female fly deposits their eggs on the surface of the host grasshopper. The egg hatches, the larva burrows into the host, and feeds on body fluids and tissue. The larva completes 3 instars, emerges from the host, and pupates in the soil. The process reduces grasshopper feeding, prevents reproduction, and with larva emergence, kills the host grasshopper (Watts et al. 1989, Hostetter 1994) (table 1).

Rangeland ants (Formicidae) are opportunistic predators of hatchling grasshoppers. The hatchling grasshoppers wriggle to the soil surface from the egg pod. They are covered by an embryonic membrane called the serosa. This membrane prevents the hatchlings from standing upright and jumping away from predatory ants. Shedding the serosa requires a few minutes of squirming by the hatchling on its side or back. After the serosa has been shed, they can stand up and jump away from the ants. The number of hatchlings captured by rangeland ants has little effect on grasshopper populations (Wheeler and Wheeler 1963, Watts et al. 1989, Hostetter 1994, Pfadt 1994) (table 1).

The larvae of 2 genera and 21 species of the minute scelionid wasps (Scelionidae) are parasites of grasshopper eggs. The adult female wasp locates grasshopper egg pods by some chemical attraction to the pod froth. The female wasp chews a passage through the froth plug to the grasshopper eggs. She extends her long ovipositor into the egg pod and lays one wasp egg per grasshopper egg. The wasp egg hatches, the larva feeds internally on the grasshopper embryo. When the wasp larva matures, it pupates within the host egg shell and emerges as an adult during summer (Dysart 1994) (table 1).

The larvae of 29 species of solitary wasps (Sphecidae) are parasites of living paralyzed adult grasshoppers. The female digger wasp catches an adult grasshopper, paralyzes it, caches it in a burrow in the soil, and deposits an egg on the live grasshopper. After the egg hatches, the wasp larva consumes the live grasshopper. These threadwaisted

wasps are usually rare in most rangeland grasshopper habitat (Watts et al. 1989, Hostetter 1994) (table 1).

Adult spiders of 9 species have been reported as predators of nymph and adult grasshoppers. The food preferences of rangeland spiders is difficult to collect. Most spiders are opportunistic and consume anything they can catch, including grasshoppers. The large nonweb building wolf spiders (Lycosidae) and jumping spiders (Salticidae) are abundant on rangelands and prey on grasshoppers. The cobweb building black widow spiders (Theridiidae) consume the grasshoppers that hop into their web (Watts et al. 1989, Hostetter 1994, Oedekoven and Joern 2000) (table 1).

The larvae of 2 species of red mite (Trombidiidae) are ectoparasites of adult grasshoppers, and at least 1 species of mite prey on grasshopper eggs at the nymph and adult stages. The mite larvae attach to the external surface of adult grasshoppers and suck blood (hemolymph). The larvae of the common species of mite attaches to the adult grasshopper at the base of the wings. The larvae of an unnamed recently found species of mite attaches to the grasshopper on the legs and antennae. The mite larvae remain feeding on the grasshopper until fully engorged. The mite larva drops off the host, burrows into the soil, and transforms into an eight legged immature nymph. The mite nymph finds grasshopper egg pods and feeds on the eggs. Each mite nymph requires more than two grasshopper eggs to become an adult. Adult male mites require three grasshopper eggs to mature and become reproductive. Adult female mites require seven to eight grasshopper eggs to mature and become reproductive. The adult mites mate while in the grasshopper egg pods. The female mite lays 300 to 700 eggs per cell. Mite larvae emerge in 28 to 30 days and attach themselves to the exoskeleton of an adult grasshopper (Watts et al. 1989, Belovsky et al. 1994, Hostetter 1994) (table 1).

The larvae of 3 species of nematodes (Mermithidae) are endoparasites of nymph grasshoppers. The nymph grasshopper becomes infected when it consumes a nematode egg that had been deposited on a grass leaf or when a hatched nematode larva penetrates the exoskeleton. The nematode larva moves to the grasshopper's body cavity and feeds on the blood (hemolymph) for 4 to 10 weeks. The mature larva exits the host grasshopper, overwinters in the soil, and molts into an adult nematode in the spring. The process kills the host grasshopper (Belovsky et al. 1994, Hostetter 1994) (table 1).

The second stage terrestrial larvae of horsehair worms (Gordiaceae) are incidental endoparasites of nymph and adult grasshoppers. Adult horsehair worms are free living in aquatic habitats. The female worm lays thousands of eggs in long strings in the water. The eggs hatch and the first larvae stage is endoparasitic of an aquatic insect host. The second larvae stage is endoparasitic of a terrestrial insect host, frequently the terrestrial host is a grasshopper (Hostetter 1994). When the mature horsehair worm, which has eaten most of the insides of the host and is, by then, several times the length of the grasshoppers' body, is ready to exit the host and return to an aquatic habitat, the parasite produces two proteins that are similar to insect type proteins and injects these proteins into the brain of the host. The proteins manipulate the host to look for water and to jump in. The worm leaves the insect, enters into the aquatic habitat, and soon develops to sexual maturity. The grasshopper is a poor swimmer and drowns (Wade 2005) (table 1).

Table 1. Rangeland grasshopper invertebrate natural enemies: pathogens, parasites, and predators.

Pathogen - a disease producing microorganism including viruses, bacteria, protozoans, and fungi.

Viruses. uncommon in grasshoppers under natural conditions.
two types found in grasshoppers.
entomopoxvirus.
crystalline array viruses.

Protozoan. unicellular animal organisms.
grasshoppers consume spore stage or eat infected cadaver.
Family: Microsporida.
Nosema locustae. attacks fat bodies, pericardial and neural tissue.
Nosema acridophagus. has potential, needs additional research.
Nosema cuneatum. has potential, needs additional research.

Fungi.

Deuteromycota. facultative, does not need grasshopper host to live.
most common.
Beauveria bassiana. white mycelial, globose conidia.
Metarhizium anisopliae. green mycelial, rod shaped conidia.
Aspergillus flavus. green mycelial, spherical conidia.

Zygomycota. obligate, needs grasshopper to live.
Entomophaga grylli. complex.
Entomophaga macleod. pathotype I.
infects Oedipodinae.
Entomophaga calopteni. pathotype II.
infects Melanoplinae.
Entomophaga praxibuli. pathotype III.
infects Gomphocerinae, Melanoplinae, and Oedipodinae.

Table 1 cont. Rangeland grasshopper invertebrate natural enemies: pathogens, parasites, and predators.

Parasites and Predators

Parasite - an organism living on (ectoparasitism) or in (endoparasitism) the body of another (host) from which the parasite obtains nutrients and contributes nothing to host.

Parasitoid - an organism that is alternately parasitic and free living, during the parasitic stage the host is consumed and killed.

Predator - an organism that hunts, captures, and kills another (prey) for food.

Phylum: Arthropoda.

Subphylum: Hexapoda.

Class: Insecta.

Order: Coleoptera (beetles).

Family: Meloidae (blister beetles). egg pod predators.

26 species.

larvae of blister beetles consume and destroy about 9% of egg pods.

Family: Carabidae (ground beetles). egg pod predators.

numerous species.

larvae of ground beetles consume and destroy about 3% of egg pods.

Order: Diptera (flies).

Family: Anthomyiidae (anthomyiid flies). endoparasite of nymphs and adults.

Acridomyia canadensis.

female fly oviposits eggs inside host body, larvae consume grasshopper.

Family: Asilidae (robber flies). predators of nymphs and adults.

26 species. can reduce grasshopper population 11% to 15%.

Northern Plains species.

Stenopogon coyote

Stenopogon neglectus

Stenopogon picticornis

Family: Bombyliidae (bee flies). egg pod predator.

13 genera.

larvae of bee flies consume and destroy about 6% of egg pods.

Family: Nemestrinidae (tangleveined flies). endoparasites of nymphs and adults.

Neorhynchocephalus sackenii

Trichopidea clausa

larvae distributed by wind, locate host, feeds inside on fat and reproductive tissue.

parasitism rates at 30% to 95% of grasshopper population.

Table 1 cont. Rangeland grasshopper invertebrate natural enemies: pathogens, parasites, and predators.

Family: Sarcophagidae (flesh flies). endoparasites of nymphs and adults.

21 to 23 species.

Prominent species.

Acridophaga aculeata

Kellymyia kellyi:

Opsophyta opifera

Protodexia hunteri

Protodexia reversa

female fly deposits larvae on or in host, larvae feed on grasshopper body fluids.

parasitism rates at 1% to 50% of grasshopper population.

Family: Tachinidae (tachinid flies). endoparasites of nymphs and adults.

Acemyia tibialis parasitism rates at 16% to 65% of grasshopper population.

Ceracia dentata parasitism rates at 1% to 5% of grasshopper population.

Hemithrixion oestriforme parasitism rates at 1% to 5% of grasshopper population.

Order: Hymenoptera (ants, wasps, bees).

Family: Formicidae (ants). predators of helpless hatchlings.

rangeland ant species.

Formica rufa obscuripes

Formica obtusopilosa

Myrmica sabuletti americana

Solenopsis molesta validiuscula

opportunistic predation of hatchlings has little effect on grasshopper population.

Family: Scelionidae (minute scelionid wasps). egg parasites.

2 genera, 21 species.

one wasp egg oviposited per grasshopper egg, wasp larvae consume grasshopper embryo.

parasitism rates destroy about 5% to 15% of egg pods.

Family: Sphecidae (solitary wasps). parasites of adults.

Subfamily: Sphecinae (threadwaisted wasp). Tribe: Ammobiini.

Prionyx parkeri

paralyzed living grasshopper placed in wasp nest with wasp egg, wasp larvae consume live grasshopper.

these wasps are generally rare in grasshopper habitat

Table 1 cont. Rangeland grasshopper invertebrate natural enemies: pathogens, parasites, and predators.

Subphylum: Chelicerata.

Class: Arachnida

Order: Araneida (spiders).

Family: Lycosidae (wolf spiders). predators of nymphs and adults.
Schizocosa sp.

Family: Salticidae (jumping spiders). predators of nymphs and adults.
Pellenes sp.

Family: Theridiidae (cobweb spiders). predators of nymphs and adults.
Latrodectus sp. (black widow spiders)

Order: Acarina (mites).

Family: Trombididae (velvet mites). ecotoparasites of adults.
Eutrombidium locustarum (red mites) on wings.
unnamed recently found mite (different red mite) on legs.
mite larvae stage attaches to grasshopper exoskeleton and sucks
blood (hemolymph) until larvae is engorged.

Phylum: Nematoda (roundworms).

Family: Mermithidae (nematodes). endoparasites of nymphs.
Agamermis decaudata
Agamospirura melanopli
Mermis nigrescens
grasshopper nymphs consume nematode eggs on vegetation, nematode larvae consumes
grasshopper.

Family: Gordiacea (horsehair worms). incidental endoparasites for nymphs and adults.
second stage terrestrial larvae seeks second host, feeds from inside grasshopper.

Vertebrate Predators

Grasshoppers provide nutritious food for rangeland amphibians, reptiles, birds, and small mammals. Grasshoppers have high energy value and contain 50% to 70% crude protein. The relatively large size of grasshoppers provides greater nutrient quantity than the amount of nutrients that small rangeland predators expend during the capture of grasshopper food (Belovsky et al. 1990).

The rangeland amphibians that prey on grasshoppers for food are adult frogs, toads, and salamanders (table 2). The rangeland reptiles that prey on grasshoppers for food are skinks, lizards, snakes, and terrestrial turtles (Over 1923, Wheeler and Wheeler 1966) (table 2).

Several rangeland birds use grasshoppers as a significant source of high quality nutrients. Nestlings and chicks must go through a period of rapid development and growth to survive their juvenile stage. Grasshoppers are important for the successful raising of young birds (Watts et al. 1989, McEwen et al. 1994). Pheasants, turkeys, prairie grouse, harriers, cooper's hawks, swainson's hawks, kestrels, plovers, sandpipers, gulls, cuckoos, shorteared owls, burrowing owls, shrikes, horned larks, bluebirds, catbirds, thrashers, grassland sparrows, dickcissels, bobolinks, and meadowlarks consume grasshoppers during the growing season for a great proportion of the juvenile food and for 30% to 90% of the adult staple diet (Jackson 1926, Bent 1968) (table 2).

Nonmigratory gallinaceous birds, notably prairie chickens and sharptailed grouse, have learned how to search and find dried grasshoppers during each month of the nongrowing season in the stacks of hay stored as livestock feed. The high crude protein content of dried grasshoppers contribute a substantial portion of the nutrients needed for the winter survival of these grouse (Manske unpublished data).

Several small rangeland mammals use grasshoppers as an important portion of their regular diet. Opossums, shrews, ground squirrels, grassland mice, raccoons, and skunks consume substantial quantities of grasshoppers when they are available (Jones et al. 1983, Chapman and Feldhamer 1992) (table 2). Predation by amphibians, reptiles, birds, and small mammals on rangeland grasshoppers has the potential force to stabilize grasshopper populations (Watts et al. 1989, Fowler et al. 1991).

Grasshoppers that have completed the morning basking period and raised their body temperature can escape predators by jumping away. Their enormous hind legs can propel a grasshopper distances of 20 times their body length. The grasshoppers' explosive jump is possible because the powerful energy force of the large muscles in the femur is stored in the elastic fibers of a semilunar crescent organ located in the knee. When a predator approaches, the released energy catapults the grasshopper away from danger (Davidowitz 2013).

Grasshoppers have numerous patterns of cryptic coloration that permit them to blend in with the background colors and textures of their habitat. These natural camouflage colorations improve the chances for individual grasshoppers to avoid being caught and eaten by predators (Anonymous 2013). Many slantfaced, Gomphocerinae, grasshoppers have horizontal light and dark bands that run most of the length of their bodies that help them mimic grass blades when they set vertically within a clump of grass. Many bandwinged, Oedipodinae, grasshoppers have cryptic coloration with the addition of deceptive escape strategies. During the short escape flight, the bandwinged grasshopper flashes the brightly colored wings and produces crepitation noises to attract attention from the predators; then upon landing the cryptic coloration hides the grasshopper, while the predator is still looking for a colorful noisy meal (Johnson 2001, Davidowitz 2013).

Table 2. Amphibian, reptilian, avian, and small mammalian predators of rangeland grasshoppers in the Northern Plains.

Class: Amphibia	Amphibians
Order: Anura	
Family: Ranidae	Frogs
<i>Rana pipiens</i>	Leopard Frog
Family: Bufonidae	Toads
<i>Bufo americanus</i>	American Toad
<i>Bufo cognatus</i>	Great Plains Toad
<i>Bufo hemiophrys</i>	Canadian or Dakota Toad
<i>Bufo woodhousei</i>	Woodhouse's Toad
Family: Ambystomatidae	Salamanders
<i>Ambystoma tigrinum</i>	Tiger Salamander
Class: Reptilia	Reptiles
Order: Squamata	
Family: Scincidae	Skinks
<i>Eumeces obsoletus</i>	Great Plains Skink
<i>Eumeces septentrionalis</i>	Prairie Skink
Family: Iguanidae	Lizards
<i>Holbrookia maculata</i>	Lesser Earless Lizard
<i>Phrynosoma douglassi</i>	Short Horned Lizard
<i>Sceloporus graciosus</i>	Sagebrush Lizard
<i>Sceloporus undulatus</i>	Northern Prairie Lizard
Family: Colubridae	Snakes
<i>Coluber constrictor</i>	Racer
<i>Heterodon nasicus</i>	Hognosed Snake
<i>Opheodrys vernalis</i>	Smooth Green Grass Snake
<i>Thamnophis radix</i>	Plains Garter Snake
<i>Thamnophis sirtalis</i>	Red sided Garter Snake
Family: Emydidae	Box Turtles
<i>Terrapene ornata</i>	Western Box Turtle
Class: Aves	Birds
Order: Galliformes	
Family: Phasianidae	Grouse
<i>Phasianus colchicus</i>	Ringnecked Pheasant
<i>Meleagris gallopavo</i>	Wild Turkey
<i>Tympanuchus cupido</i>	Greater Prairie Chicken
<i>Tympanuchus phasianellus</i>	Sharptailed Grouse
<i>Centrocercus urophasianus</i>	Greater Sage Grouse

Table 2 cont. Amphibian, reptilian, avian, and small mammalian predators of rangeland grasshoppers in the Northern Plains.

Order: Falconiformes

Family: Accipitridae	Hawks
<i>Circus cyaneus</i>	Northern Harrier
<i>Accipiter cooperii</i>	Cooper's Hawk
<i>Buteo swainsoni</i>	Swainson's Hawk
Family: Falconidae	Falcons
<i>Falco sparverius</i>	American Kestrel

Order: Charadriiformes

Family: Charadriidae	Plovers
<i>Charadrius vociferus</i>	Killdeer
Family: Scolopacidae	Sandpipers
<i>Limosa fedoa</i>	Marbled Godwit
<i>Bartramia longicauda</i>	Upland Sandpiper
Family: Laridae	Gulls
<i>Larus pipixcan</i>	Franklin's Gull
<i>Chlidonias niger</i>	Black Tern

Order: Cuculiformes

Family: Cuculidae	Cuckoos
<i>Coccyzus americanus</i>	Yellowbilled Cuckoo
<i>Coccyzus erythrophthalmus</i>	Blackbilled Cuckoo

Order: Strigiformes

Family: Strigidae	Owls
<i>Asio flammeus</i>	Shorteared Owl
<i>Athene cunicularia</i>	Burrowing Owl

Order: Passeriformes

Family: Laniidae	Shrikes
<i>Lanius ludovicianus</i>	Loggerhead Shrike
Family: Alaudidae	Larks
<i>Eremophila alpestris</i>	Horned Lark
Family: Turdidae	Thrushes
<i>Sialia sialis</i>	Bluebird
<i>Sialia currucoides</i>	Mountain Bluebird

Table 2 cont. Amphibian, reptilian, avian, and small mammalian predators of rangeland grasshoppers in the Northern Plains.

Family: Mimidae	Mockingbirds
<i>Dumetella carolinensis</i>	Gray Catbird
<i>Toxostoma rufum</i>	Brown Thrasher
Family: Emberizidae	Sparrows
<i>Spizella pusilla</i>	Field Sparrow
<i>Spizella breweri</i>	Brewer's Sparrow
<i>Chondestes grammacus</i>	Lark Sparrow
<i>Ammodramus savannarum</i>	Grasshopper Sparrow
<i>Ammodramus bairdii</i>	Baird's Sparrow
<i>Calamospiza melanocorys</i>	Lark Bunting
<i>Passerculus sandwichensis</i>	Savannah Sparrow
<i>Pooecetes gramineus</i>	Vesper Sparrow
<i>Calcarius ornatus</i>	Chestnut Collared Longspur
<i>Calcarius mccownii</i>	McCown's Longspur
Family: Cardinalidae	Cardinals
<i>Spiza americana</i>	Dickcissel
Family: Icteridae	Black birds
<i>Dolichonyx oryzivorus</i>	Bobolink
<i>Sturnella neglecta</i>	Meadowlark
Class: Mammalia	Mammals
Order: Marsupialia	
Family: Didelphidae	Opossums
<i>Didelphis virginiana</i>	Virginia Opossum
Order: Insectivora	
Family: Soricidae	Shrews
<i>Sorex arcticus</i>	Arctic Shrew
<i>Sorex cinereus</i>	Masked Shrew
Order: Rodentia	
Family: Sciuridae	Squirrels
<i>Spermophilus franklinii</i>	Franklin's Ground Squirrel
<i>Spermophilus richardsonii</i>	Richardson's Ground Squirrel
<i>Spermophilus tridecemlineatus</i>	Thirteenlined Ground Squirrel
Family: Cricetidae	Mice
<i>Peromyscus maniculatus</i>	Deer Mouse
<i>Onychomys leucogaster</i>	Grasshopper Mouse
Order: Carnivora	
Family: Procyonidae	Raccoons
<i>Procyon lotor</i>	Raccoon
Family: Mustelidae	Weasels
<i>Mephitis mephitis</i>	Striped Skunk