

Pestiferous Rangeland Grasshoppers

There are about 600 grasshopper species (Hewitt and Onsager 1982b) in North America, nearly 400 grasshopper species inhabit the western portion, of which, 70 of these species are common (Pfadt 1994), and 200 of these grasshopper species exist on rangelands (Onsager 1987); 25 rangeland grasshopper species regularly reach densities that cause economic damage (Hewitt and Onsager 1983), 12 rangeland grasshopper species frequently occur in high densities, and another 12 species occasionally occur in high densities (Hewitt and Onsager 1983). In spite of these specific numbers, a definitive list in which grasshopper species were characterized as frequently pestiferous, occasionally pestiferous, sometimes pestiferous, potentially pestiferous, and nonpestiferous was not located. However, numerous regional lists compiled by entomologists from various states and provinces identified the problem grasshopper species in the Northern Plains, albeit, placing them into several different severity categories (Watts et al. 1989, Cushing 1993, Pfadt 1994, Dysart 1996, Foster 1996b, Onsager 2000, Calpas and Johnson 2003, Schell et al. 2004, Campbell et al. 2006) (table 3).

The most commonly used category to distinguish pestiferous rangeland grasshoppers was any harmful grasshopper species that had increased its population to infestation levels and consumed or destroyed sufficient quantities of livestock forage to cause economic damage (Johnson 2001, 2002, 2003; APHIS 2002, Campbell et al. 2006, Brust et al. 2008). The various degrees of ecosystem deterioration caused by grasshopper species has had little scientific attention. Some grasshopper species have the ability to seriously injure young growing grass tillers and cause ecosystem degradation before their densities reach threshold outbreak levels. For the purposes of this report, grasshopper species that cause ecological degradation to rangeland ecosystems will also be accepted as pestiferous. Thus, the included list of pestiferous rangeland grasshopper species in the Northern Plains is a divergent concession with no pretense of being resolute (table 4).

The Northern Plains is comprised of all or parts of the states of Montana, Nebraska, North Dakota, South Dakota, and Wyoming, and the provinces of Alberta, Manitoba, and Saskatchewan (figure 1). The distribution of the pestiferous rangeland grasshoppers is throughout the Northern Plains. All the pest grasshoppers occur in each state and province, except three pest grasshoppers do not

occur in one of the prairie provinces each (Pfadt 1994) (table 5).

Eight (35%) of the pestiferous rangeland grasshoppers are small size grasshoppers; 6 (75%) are members of the Gomphocerinae (slantfaced) subfamily, 1 (12.5%) is a member of the Melanophinae (spurthroated) subfamily, and 1 (12.5%) is a member of the Oedipodinae (bandwinged) subfamily. The average small size adult male grasshopper has a live weight of 119.4 mg and a body length of 16.5 mm. The average small size adult female grasshopper has a live weight of 255.9 mg and a body length of 20.6 mm (table 6).

Eleven (48%) of the pestiferous rangeland grasshoppers are medium size grasshoppers; 3 (27%) are members of the Gomphocerinae (slantfaced) subfamily, 6 (55%) are members of the Melanophinae (spurthroated) subfamily, and 2 (18%) are members of the Oedipodinae (bandwinged) subfamily. The average medium size adult male grasshopper has a live weight of 235.7 mg and a body length of 19.0 mm. The average medium size adult female grasshopper has a live weight of 460.2 mg and a body length of 23.3 mm (table 6).

Four (17%) of the pestiferous rangeland grasshoppers are large size grasshoppers; 3 (75%) are members of the Melanophinae (spurthroated) subfamily, and 1 (25%) is a member of the Oedipodinae (bandwinged) subfamily. The average large size adult male grasshopper has a live weight of 471.3 mg and a body length of 27.3 mm. The average large size adult female grasshopper has a live weight of 851.0 mg and a body length of 33.9 mm (table 6).

Table 3. Identification of pestiferous rangeland grasshoppers in the Northern Plains.

Pestiferous Rangeland Grasshoppers	A NP	B ND	C NA	D NA	MT	NE	E ND	SD	WY	F ND	G AB	H NE
Aer cla	X	X	X	32			X					
Age deo	X	X	X	5	X	X	X	X	X	X		X
Amp col	X	X	X	8	X		X	X	X			X
Aul ell	X	X	X	2	X		X	X	X			X
Aul fem	X			12					X	X		X
Cam pel	X	X	X	3	X		X		X		X	
Cor occ	X		X	15					X	X		X
Enc cos	X			34						X		
Eri sim	X			26		X	X				X	
Mel biv		X	X	4	X				X		X	
Mel con		X		48			X					
Mel dif			X	10					X	X		
Mel fem		X	X	7		X		X	X	X		
Mel gla		X		21		X				X		
Mel inf	X	X	X	13	X		X	X	X	X	X	
Mel occ				18					X			
Mel pac		X	X	6	X				X		X	
Mel san	X	X	X	1	X		X	X	X	X	X	X
Met par		X	X	25								
Ope obs	X			14		X	X	X	X	X		
Phl qua	X	X	X	9	X	X	X	X	X			X
Pho neb	X			16		X		X		X		X
Tra kio	X	X	X	11	X		X	X	X	X		X

A. Watts et al. 1989; B. Cushing 1993; C. Pfadt 1994; D. Dysart 1996; E. Foster 1996b, and Schell et al. 2004; F. Onsager 2000; G. Calpas and Johnson 2003; H. Campbell et al. 2006.

Table 4. Pestiferous rangeland grasshoppers in the Northern Plains.

Aer cla	<i>Aeropedellus clavatus</i>	(Thomas)	Clubhorned Grasshopper
Age deo	<i>Ageneotettix deorum</i>	(Scudder)	Whitewhiskered Grasshopper
Amp col	<i>Amphitornus coloradus</i>	(Thomas)	Striped Grasshopper
Aul ell	<i>Aulocara elliotti</i>	(Thomas)	Bigheaded Grasshopper
Aul fem	<i>Aulocara femoratum</i>	(Scudder)	Whitecrossed Grasshopper
Cam pel	<i>Camnula pellucida</i>	(Scudder)	Clearwinged Grasshopper
Cor occ	<i>Cordillacris occipitalis</i>	(Thomas)	Spottedwinged Grasshopper
Enc cos	<i>Encoptolophus costalis</i>	(Scudder)	Dusky Grasshopper
Eri sim	<i>Eritettix simplex</i>	(Scudder)	Velvetstriped Grasshopper
Mel biv	<i>Melanoplus bivittatus</i>	(Say)	Twostriped Grasshopper
Mel con	<i>Melanoplus confusus</i>	(Scudder)	Pasture Grasshopper
Mel dif	<i>Melanoplus differentialis</i>	(Thomas)	Differential Grasshopper
Mel fem	<i>Melanoplus femurrubrum</i>	(DeGeer)	Redlegged Grasshopper
Mel gla	<i>Melanoplus gladstoni</i>	(Scudder)	Gladston Grasshopper
Mel inf	<i>Melanoplus infantilis</i>	(Scudder)	Little Spurthroated Grasshopper
Mel occ	<i>Melanoplus occidentalis</i>	(Thomas)	Flabellate Grasshopper
Mel pac	<i>Melanoplus packardii</i>	(Scudder)	Packard Grasshopper
Mel san	<i>Melanoplus sanguinipes</i>	(Fabricius)	Migratory Grasshopper
Met par	<i>Metator pardalinus</i>	(Saussure)	Bluelegged Grasshopper
Ope obs	<i>Opeia obscura</i>	(Thomas)	Obscure Grasshopper
Phl qua	<i>Phlibostroma quadrimaculatum</i>	(Thomas)	Fourspotted Grasshopper
Pho neb	<i>Phoetaliotes nebrascensis</i>	(Thomas)	Largeheaded Grasshopper
Tra kio	<i>Trachyrhachys kiowa</i>	(Thomas)	Kiowa Grasshopper

Table 5. Distribution of pesiferous rangeland grasshoppers in the Northern Plains.

Pestiferous Rangeland Grasshoppers	Montana	Nebraska	North Dakota	South Dakota	Wyoming	Alberta	Manitoba	Saskatchewan
	MT	NE	ND	SD	WY	AB	MB	SK
Aer cla	X	X	X	X	X	X	X	X
Age deo	X	X	X	X	X	X	X	X
Amp col	X	X	X	X	X	X	X	X
Aul ell	X	X	X	X	X	X	X	X
Aul fem	X	X	X	X	X	X		X
Cam pel	X	X	X	X	X	X	X	X
Cor occ	X	X	X	X	X	X	X	X
Enc cos	X	X	X	X	X	X	X	X
Eri sim	X	X	X	X	X	X		X
Mel biv	X	X	X	X	X	X	X	X
Mel con	X	X	X	X	X	X	X	X
Mel dif	X	X	X	X	X		X	X
Mel fem	X	X	X	X	X	X	X	X
Mel gla	X	X	X	X	X	X	X	X
Mel inf	X	X	X	X	X	X	X	X
Mel occ	X	X	X	X	X	X	X	X
Mel pac	X	X	X	X	X	X	X	X
Mel san	X	X	X	X	X	X	X	X
Met par	X	X	X	X	X	X	X	X
Ope obs	X	X	X	X	X	X	X	X
Phl qua	X	X	X	X	X	X	X	X
Pho neb	X	X	X	X	X	X	X	X
Tra kio	X	X	X	X	X	X	X	X

Information from geographic range maps developed by Pfadt 1994.

Table 6. Live weight and body length of adult pestiferous rangeland grasshoppers.

Pestiferous Rangeland Grasshoppers	Sex	Adult Live Weight mg	Adult Body Length mm
Small size grasshoppers			
<i>Aeropedellus clavatus</i>	male		17.0-17.5
	female		19.5-21.0
<i>Ageneotettix deorum</i>	male	110	15.5-16.2
	female	310	21.0-24.0
<i>Amphitornus coloradus</i>	male	144	17.8-20.3
	female	275	21.5-25.0
<i>Cordillacris occipitalis</i>	male	101	16.5-18.5
	female	224	21.0-23.5
<i>Melanoplus infantilis</i>	male	157	16.5-17.0
	female	236	16.0-19.0
<i>Opeia obscura</i>	male	66	13.5-15.0
	female	143	18.0-19.7
<i>Phlibostroma quadrimaculatum</i>	male	110	14.5-15.0
	female	300	18.5-21.5
<i>Trachyrhachys kiowa</i>	male	148	15.0-18.0
	female	303	17.0-24.0

Table 6 cont. Live weight and body length of adult pestiferous rangeland grasshoppers.

Pestiferous Rangeland Grasshoppers	Sex	Adult Live Weight mg	Adult Body Length mm
Medium size grasshoppers			
<i>Aulocara ellioti</i>	male	180	17.0-20.0
	female	474	20.5-25.0
<i>Aulocara femoratum</i>	male	141	15.1-17.0
	female	460	20.0-25.0
<i>Camnula pellucida</i>	male	201	19.5-21.5
	female	605	22.0-25.0
<i>Encoptolophus costalis</i>	male	168	15.0-18.5
	female	468	21.5-25.5
<i>Eritettix simplex</i>	male	108	15.0-16.5
	female	269	22.0-23.5
<i>Melanoplus confusus</i>	male		18.0-19.0
	female		23.0-24.0
<i>Melanoplus femurrubrum</i>	male	289	17.5-23.0
	female	389	24.0-28.0
<i>Melanoplus gladstoni</i>	male	446	19.0-22.5
	female	509	20.1-25.2
<i>Melanoplus occidentalis</i>	male	280	19.2-21.0
	female	567	22.0-24.0
<i>Melanoplus sanguinipes</i>	male	338	20.0-26.0
	female	442	20.0-29.0
<i>Phoetaliotes nebrascensis</i>	male	206	17.8-19.4
	female	419	20.5-22.5

Table 6 cont. Live weight and body length of adult pestiferous rangeland grasshoppers.

Pestiferous Rangeland Grasshoppers	Sex	Adult Live Weight mg	Adult Body Length mm
Large size grasshoppers			
<i>Melanoplus bivittatus</i>	male	549	28.0-30.0
	female	1,086	36.0-41.0
<i>Melanoplus differentialis</i>	male		22.0-32.0
	female		30.0-33.0
<i>Melanoplus packardii</i>	male	571	27.0-32.0
	female	639	32.0-35.5
<i>Metator pardalinus</i>	male	294	22.0-25.0
	female	828	30.0-34.0

Live weight and body length of adult male and female from Pfadt 1994.

Life History of the clubhorned grasshopper

Aeropedellus clavatus (Thomas) (Aer cla), the clubhorned grasshopper, is a frequent dominant pest on rangelands, primarily in the prairie provinces and in North Dakota on sand prairie and it can be injurious to grassland ecosystems because it is able to consume substantial quantities of leaves from young native grass tillers prior to the 3.5 new leaf stage, and it is a subdominant pest on croplands. The clubhorned grasshopper has wide distribution in western North America and it inhabits the rangelands of the Northern Plains. It is a member of the Gomphocerinae subfamily of slantfaced grasshoppers. The adults are small sized grasshoppers. Body length of the males is 0.67 to 0.69 in (17.0 to 17.5 mm) and the females is 0.77 to 0.83 in (19.5 to 21.0 mm).

The hatching period is with the very early group starting about early May and lasting 3 to 4 weeks. The nymphs develop rapidly through 4 instar stages in about 30 days. The fledgling adults require a period for growth and maturation after they appear. The males court the females with an intraspecific stridulation song. Females require a period for egg development after mating. Gravid females deposit 5 to 8 eggs per clutch in a pod that is 0.39 to 0.51 in (10 to 13 mm) long and 0.14 to 0.16 in (3.5 to 4.0 mm) in diameter placed vertically into the bare soil near the roots of grasses or sedges. The eggs develop rapidly to stage 26 (95%), then enter diapause; the following spring, the embryos complete development to stage 27 and emerge very early.

The clubhorned grasshopper is graminivorous and feeds on grasses and sedges. In the mixed grass prairie, the main food plants are

western wheatgrass, prairie junegrass, sandberg bluegrass, needle and thread, threadleaf sedge, needleleaf sedge, and kentucky bluegrass. Small amounts of grass seeds, forbs, fungi, pollen, and arthropod parts are consumed.

Typical densities on rangeland are 1 to 2 adults/yd² (1.2 to 2.4/m²). The clubhorned grasshopper is geophilous and spends most of the time on the ground. The adults remain in the same area that they hatched. The females have short wings and do not fly. The males can have either short or long wings. Males with long wings frequently take short flights but do not go far from the females. *Aeropedellus clavatus* is one of the preferred hosts of the endoparasite *Neorhynchocephalus sackenii* (tangleveined fly); the fly larvae consume the grasshopper from inside.

The clubhorned grasshopper has been the dominant species increasing to adult densities of 20/yd² (24/m²) during outbreaks in the sand prairies of the prairie provinces of Canada and southeastern North Dakota. During infestations in Montana, North Dakota, and Saskatchewan on rangelands that have less favorable silty or clayey soil types, the clubhorned grasshopper frequently was abundant in the grasshopper assemblages as a codominant and contributed at a reduced level to the severe damage caused to forage grasses and to cereal grain plants in nearby fields.

This summary life history of the clubhorned grasshopper was based primarily from the work of Pfadt 1994 with additional information from Mulkern et al. 1969, Watts et al. 1989, and Hostetter 1994.

Life History of the whitethiskered grasshopper

Ageneotettix deorum (Scudder) (Age deo), the whitethiskered grasshopper, is a frequent serious dominant pest on rangelands, primarily in the mixed grass prairie and it is a pest on crested wheatgrass pastures in western North Dakota. It requires dry upland native prairie with short grasses and open bare areas. The whitethiskered grasshopper has wide distribution in North America and it inhabits the rangelands of the Northern Plains. It is a member of the Gomphocerinae subfamily of slantfaced grasshoppers. The adults are small sized grasshoppers. Live weight of the males average 110 mg and the females average 310 mg. Body length of the males is 0.61 to 0.64 in (15.5 to 16.2 mm) and the females is 0.83 to 0.94 in (21.0 to 24.0 mm).

The hatching period is with the early group starting about mid May and lasting 4 to 6 weeks. The nymphs usually develop through 5 instar stages in 40 to 48 days, however, some males require only 4 instars and some females require 6 instars. The fledgling adults require a period for growth and maturation after they appear. Females have a preoviposition period of 14 days between fledging and ovipositing the first clutch of eggs. The males court the females with visual signals of raising and lowering the hind femurs and its antennae. Females require a period for egg development after mating. Gravid females deposit 3 to 5 eggs per clutch in a tough curved pod that is 0.39 to 0.47 in (10 to 12 mm) long and 0.16 in (4 mm) in diameter placed at a shallow depth horizontally just below the surface into bare ground or near blue grama or buffalograss. The eggs begin embryonic growth in the summer of deposition and continue until they attain 50% development (stage 19), then enter obligatory diapause; the following spring, the embryos complete development to stage 27 and emerge.

The whitethiskered grasshopper is graminivorous and feeds on grasses and sedges. The main food plants are blue grama, western wheatgrass, needle and thread, threadleaf sedge, needleleaf sedge, sandberg bluegrass, and kentucky bluegrass. Preferentially, they feed from the ground, they reach up, sever the grass leaves from the plant, then eat the

leaf while sitting on the ground. Adults sometimes cling to grass plants and feed on the leaves in a head down position while remaining on the plant. Small amounts of forbs, grass seeds, felled leaf parts, dry plant litter, cattle dung, and arthropod parts are also consumed from the soil surface.

At typical low densities, the adults remain in the same area that they hatched. They are diurnal, active during the day and inactive at night. The whitethiskered grasshopper is geophilous and spends most of the day and all of the night on the ground. After sunrise and before sunset, they bask on the ground by resting perpendicular to the rays of the sun and by hugging the ground surface. Adults perform normal activities of mating, egg laying, feeding, and pottering (walking around aimlessly). The percent time engaged in daily activities was 81.8% basking, 13.0% pottering, and 4.4% feeding. During the afternoons that the soil temperatures become too hot at 120° F (49° C), individuals seek the shade of small shrubs and rest on the bare ground or litter. *Ageneotettix deorum* is one of the preferred hosts of the endoparasite *Neorhynchocephalus sackenii* (tangleveined fly); the fly larvae consumes the grasshopper from inside.

The whitethiskered grasshopper has frequently been the dominant species in grasshopper assemblages infesting the mixed grass prairie. The population numbers commonly increase gradually at 1.5 to 3 fold annually for about 4 years and then with a sudden increase of 6 fold that causes an outbreak with an adult population of around 50/yard² (60/m²). The high densities usually remain for 3 to 5 years before the population crashes back to low levels. Usually the whitethiskered grasshopper contributes 50% of the high density. The remaining assemblage can include bigheaded, spottedwinged, striped, and kiowa grasshoppers.

This summary life history of the whitethiskered grasshopper was based primarily from the work of Pfadt 1994 with additional information from Mulkern et al. 1969, Heidorn and Joern 1984, Watts et al. 1989, Belovsky et al. 1990, Hostetter 1994, Jech 1996, Joern 1996c, Fisher et al. 1996a, and Onsager 2000.

Life History of the striped grasshopper

Amphitornus coloradus (Thomas) (Amp col), the striped grasshopper, is a common codominant pest on rangelands with increased economic importance on western mid and short grass rangelands. The striped grasshopper has wide distribution in western North America and it inhabits the rangelands of the Northern Plains. It is a member of the Gomphocerinae subfamily of slantfaced grasshoppers. The adults are small sized grasshoppers. Live weight of the males average 144 mg and the females average 275 mg. Body length of the males is 0.70 to 0.80 in (17.8 to 20.3 mm) and the females is 0.85 to 0.98 in (21.5 to 25.0 mm).

The hatching period is with the early group starting about mid to late May and lasting 4 to 5 weeks. The nymphs develop slowly through 5 instar stages in 50 to 56 days. The fledgling adults require a period for growth and maturation after they appear. The males court the females with a brief intraspecific stridulation song. Females require a period for egg development after mating. Gravid females deposit 4 eggs per clutch in a tough, thimble-shaped pod that is 0.28 to 0.32 in (7 to 8 mm) long and 0.12 to 0.16 in (3 to 4 mm) in diameter placed below the soil surface at the center of the crown of needle and thread or threadleaf sedge. The eggs begin embryonic growth in the summer of deposition, continue until stage 19 (50%), then enter diapause; the following spring, the embryos complete development to stage 27 and emerge.

The striped grasshopper is graminivorous and feeds mostly on grasses and sedges. The main food plants are blue grama, needle and thread, threadleaf sedge, and needleleaf sedge; sometimes they feed on western wheatgrass, prairie junegrass, sandberg bluegrass, and sand dropseed. Preferentially, they feed from the ground, they reach up, sever the grass leaves from the plant, then eat the leaf while sitting on the ground. Sometimes, the grasshopper climbs on the grass plant to feed. The striped grasshopper spend the nonfeeding periods within clumps of grass on a stem or leaf in the upright

position. Its cryptic body markings make it difficult for predators to find. Rarely they will feed on the ground and consume small amounts of forbs, arthropod parts, and fungi. This grasshopper does not eat dry litter.

Typical low densities on rangeland are 0.1 to 0.8/yard² (0.12 to 1.0/m²). The adults have long wings and the power of strong flights, however, most adults remain in the same area that they hatched. They spend part of the day on vegetation and part on the ground; and they spend all of the night inactive on the ground. After sunrise and before sunset, they bask on the ground by exposing their side or back to the rays of the sun and by hugging the ground. Adults perform normal activities of mating, feeding, and pottering (walking around aimlessly). The percent time engaged in daily activities was 77.4% basking, 8.4% pottering, and 14.2% feeding. During summer afternoons that the air temperatures rise above 90° F (32° C), the adults climb small shrubs and rest head up 2 to 8 inches (5.1 to 20.3 cm) above the ground in the shade to reduce body temperature through evaporative cooling by hyperventilation.

The population density of the striped grasshopper may remain low for long periods of up to 9 years. The population density usually grows gradually at 2 fold annually for about 3 to 4 years and then increase at 3 or 4 fold that causes an outbreak with an adult striped grasshopper density that generally exceeds 8/yard² (9.6/m²). The striped grasshopper is rarely the dominant species during the outbreak. The other grasshoppers of the outbreak assemblage are the bigheaded, whitewiskered, and spottedwinged grasshoppers that had parallel population growth reaching combined densities of 20 to 40/yard² (24 to 48/m²). All of the assemblage grasshoppers contribute to the economical damage to the rangelands.

This summary life history of the striped grasshopper was based primarily from the work of Pfadt 1994 with additional information from Mulkern et al. 1969, Watts et al. 1989, Belovsky et al. 1990, Carruthers et al. 1992, and Jech 1996.

Life History of the bigheaded grasshopper

Aulocara ellioti (Thomas) (Aul ell), the bigheaded grasshopper, is a serious major dominant pest and is among the most damaging species on rangelands, primarily in the mixed and short grass prairies and it can be injurious to grassland ecosystems because it is able to consume substantial quantities of leaves from young native grass tillers prior to the 3.5 new leaf stage. It prefers arid grassland habitat of short grasses with open bare ground between plant clumps. The bigheaded grasshopper has wide distribution in western North America and it inhabits the rangelands of the Northern Plains. It is a member of the Gomphocerinae subfamily of slantfaced grasshoppers. The adults are medium sized grasshoppers. Live weight of the males average 180 mg and the females average 474 mg. Body length of the males is 0.67 to 0.79 in (17.0 to 20.0 mm) and the females is 0.81 to 0.98 in (20.5 to 25.0 mm).

The hatching period is with the early group starting about mid May and lasting 3 to 4 weeks. The nymphs complete development in 36 to 42 days; the males with usually 4 instar stages and the females with 5 instar stages. The fledgling adults require a period for 6 to 8 days for growth and maturation after they appear. The males court the females with visual cues by tipping the hind femur and waving their antennae. Females require a period for egg development after mating. Gravid females deposit 7 to 9 eggs per clutch in a tough slightly curved pod that is 0.5 to 0.63 in (12.7 to 15.9 mm) long and 0.19 in (4.8 mm) in diameter placed horizontally into bare ground at a shallow depth of 0.5 in (12.7 mm) just below the surface. The eggs begin embryonic growth in the summer of deposition, continue until stage 19 (50%), then enter obligatory diapause; the following spring, the embryos resume development at the base soil temperature of 50°F (10° C) and complete development to stage 27 after 450 DD (degree days) of heat and emerge.

The bigheaded grasshopper is graminivorous and feeds mainly on the green leaves of grasses and sedges. The main food plants are blue grama, western wheatgrass, needle and thread, threadleaf sedge, needleleaf sedge, and crested wheatgrass. The grasshopper climbs up a leaf blade, turns around head

down and chews on the leaf; frequently the chewing cuts through the leaf and the above portion drops to the ground while the grasshopper continues feeding on the lower portions of the leaf. Sometimes they feed on the ground and consume small amounts of dropped grass leaves, seeds, dry plant litter, and arthropod parts.

The adults have fully developed wings and are able to fly. During the typical low densities, the adults remain in the same area that they hatched. The bigheaded grasshopper is geophilous and spends most of the day and all of the night on the ground. After sunrise and before sunset, they bask on the ground by resting with their side exposed to the rays of the sun and by hugging the ground. When soil temperatures are 95° F (35° C) or greater, and air temperatures are 70° F (21° C) or greater, the adults perform normal activities of mating, egg laying, feeding, and pottering (walking around aimlessly). The percent time engaged in daily activities was 69.5% basking, 17.2% pottering, and 13.2% feeding. During summer afternoons when the soil temperatures rise to 120° F (49° C), individuals stilt by raising up on their legs and hold their bodies off the ground, then they seek the shade of small shrubs and rest on the bare soil or litter.

Populations of the bigheaded grasshopper irrupt frequently in the mixed grass prairie. The population numbers commonly increase gradually at 2 fold annually for 3 to 4 years, and then in 1 year the density increases at 3 or 4 fold that causes an outbreak with an adult population of around 20/yard² (24/m²). The high population densities usually remain for 5 or more years before the population crashes. The high densities of grasshoppers can destroy rangeland in one area causing them to move to another area. The bigheaded grasshopper is often the dominant species of an outbreak assemblage along with spottedwinged, whitewiskered, striped, and kiowa grasshoppers.

This summary life history of the bigheaded grasshopper was based primarily from the work of Pfadt 1994 with additional information from Mulhern et al. 1969, Hewitt, Burleson, and Onsager 1976, Watts et al. 1989, Jech 1996, Fisher et al. 1996a, and Onsager 2000.

Life History of the whitecrossed grasshopper

Aulocara femoratum (Scudder) (Aul fem), the whitecrossed grasshopper, is an important codominant pest on rangelands, primarily in the mixed grass prairie on areas with abundant short grasses and it is a major pest in Nebraska. It prefers grassland habitat of short grasses with open bare ground between plant clumps. The whitecrossed grasshopper has wide distribution in western North America and it inhabits the rangelands of the Northern Plains that have abundant western wheatgrass, needle and thread, and blue grama. It is a member of the Gomphocerinae subfamily of slantfaced grasshoppers. The adults are medium sized grasshoppers. Live weight of the males average 141 mg and the females average 460 mg. Body length of the males is 0.59 to 0.67 in (15.1 to 17.0 mm) and the females is 0.79 to 0.98 in (20.0 to 25.0 mm).

The hatching period is with the intermediate group starting early June and lasting 2 weeks. The male nymphs develop through 4 instar stages in 30 or more days. The female nymphs develop through 5 instar stages in 42 or more days. The females are 3 times the size of the males. The adults appear during the first and second weeks of July and mature in about 3 weeks. The males court the females with stridulation movements, however, no humans have heard the song. Females require a period for egg development after mating. Gravid females deposit 9 to 11 eggs per clutch in a strong thick walled pod that is 0.56 to 0.63 in (14.3 to 15.9 mm) long and 0.25 in (6.4 mm) in diameter placed into bare ground at a depth of 0.75 in (19.1 mm). The bare soil egg laying site is usually surrounded by blue grama or other short grasses. Accumulation of heat units is slowed because of the relatively deep deposition of the eggs. The eggs begin embryonic growth in the summer of deposition and continue until they enter diapause; the following spring, the embryos complete development and emerge.

The whitecrossed grasshopper is graminivorous and feeds on grasses and sedges. The main food plants are western wheatgrass, needle and thread, blue grama, prairie junegrass, and needleleaf

sedge. The diets of males and females are different. The males ingest larger amounts of short grasses and sedges and the females ingest more mid grasses. The grasshopper climbs up a leaf blade, turns around head down, and feeds on the blade edge leaving a narrow strip on the opposite side. The males walk extensively on the ground searching for females and come in contact mostly with short grasses. The females are more sedentary and usually climb and feed on mid grasses.

Adults have relatively short wings but have the capacity to fly and disperse. During typical low densities of 0.1 to 2/yard² (0.12 to 2.4/m²), the adults remain in the same area that they hatched. The whitecrossed grasshopper is geophilous and spends most of the day and all of the night on the ground. At night, both nymphs and adults rest on bare soil interspersed among grassy vegetation. After sunrise and before sunset, they bask on the ground by resting with their side exposed to the rays of the sun. During the morning basking period, the soil temperatures range from 60° to 90°F (16° to 32° C) and air temperatures are from 61° to 82°F (16° to 28° C). When soil temperatures are 90° F (32° C) or greater and air temperatures are 82° F (28° C) or greater, the adults perform normal activities of courting, mating, feeding, and pottering. On summer afternoons when the soil temperatures rise; individuals still by raising up on their legs and hold their bodies off the hot ground, then they may crawl onto a short grass or sedge plant and rest facing the sun, or they may climb stems of mid grasses to heights of 2 to 7 inches (5.1 to 17.8 cm) and reduce their body temperature through evaporative cooling by hyperventilation.

Populations of the whitecrossed grasshopper can increase from low to high densities of 8 to 13/yard² (9.6 to 15.6/m²) in 1 year. The whitecrossed grasshopper is usually a codominant member of an outbreak assemblage in which bigheaded and bluelegged grasshoppers are more numerous with combined densities of 20 to 25/yard² (24 to 30/m²).

This summary life history of the whitecrossed grasshopper was based primarily from the work of Pfadt 1994 with additional information from Watts et al. 1989, and Carruthers et al. 1992.

Life History of the clearwinged grasshopper

Camnula pellucida (Scudder) (Cam pel), the clearwinged grasshopper, is a severe dominant pest on rangelands, primarily in the northern mixed grass prairie and it is a major pest on croplands. It has adapted to cropland agricultural practices and can damage or destroy cereal grain and vegetable crops during outbreaks. The clearwinged grasshopper has wide distribution across North America and it inhabits the rangelands of the Northern Plains. It is a member of the Oedipodinae subfamily of bandwinged grasshoppers. The adults are medium sized grasshoppers. Live weight of the males average 201 mg and the females average 605 mg. Body length of the males is 0.77 to 0.85 in (19.5 to 21.5 mm) and the females is 0.87 to 0.98 in (22.0 to 25.0 mm).

The hatching period is with the early group starting about mid to late May in egg beds on native sod and lasting 2 to 5 weeks. The nymphs quickly develop through 5 instar stages in 26 to 40 days. The adults appear first as dark colored. The fledgling adults require a period for growth and maturation after they appear; male requires 5 to 7 days and females require 7 to 10 days. As they mature they turn bright yellow. The males court the females with an intraspecific stridulation song, and the males hold their antennae in an upright V-shape. The males usually remain on the egg beds during the courtship period. The females move between the feeding ground and the egg beds. The egg beds are on grass sod, usually the same area of native sod that was used the previous year. Females require a period for egg development after mating. Gravid females deposit 10 to 38 eggs per clutch in a short stout slightly curved pod that is 0.63 in (15.9 mm) long and 0.19 in (4.8 mm) in diameter placed into bare ground in the top inch (2.5 cm) of soil near grass roots. The eggs begin embryonic growth in the summer of deposition, continue development to stage 19 (50%) after 400 DD (degree days) of heat, then enter diapause until low soil temperatures during winter break diapause; the following spring, the embryos resume development at the base soil temperature of 55° F (12.8° C) and complete development to stage 27 after 150 DD (degree days) of heat and, at the soil temperature of 80° F (26.7° C), the nymphs emerge.

The clearwinged grasshopper is graminivorous and feeds mainly on grasses. The wide variety of food plants include Idaho fescue, red fescue, sandberg bluegrass, western wheatgrass, intermediate wheatgrass, slender hairgrass, Kentucky bluegrass, crested wheatgrass, smooth brome, downy brome, and soft brome. Generally, they climb

in or on the grass plant to feed. Sometimes they consume small amounts of forbs.

The clearwinged grasshopper populations can remain on rangeland at low densities for 5 to 10 years. They are diurnal, active during the day and inactive at night. The clearwinged grasshopper is geophilous and spends most of the time on the ground. At night, they seek warm stones and sheltered places. After sunrise and before sunset, they bask by resting on bare ground, earth clods, or dried cattle dung with their sides exposed to the rays of the sun. During the day, they move about and feed while the ground temperature range from 95° to 102° F (35° to 39° C) and air temperatures are around 67° to 75° F (19° to 24° C). During the summer afternoons when the soil temperatures rise to 107° F (42° C), individuals move to shade and climb 2 inches (5.1 cm) up plant stems and reduce their body temperatures through evaporative cooling by hyperventilation. *Camnula pellucida* is one of the preferred hosts of the endoparasite *Neorhynchocephalus sackenii* (tangleveined fly); the fly larvae consumes the grasshopper from inside.

Populations of clearwinged grasshopper increase gradually over 3 to 4 years. The outbreaks consist almost entirely of only 1 species. The young nymphs move away from the egg beds as food plants are depleted. The older instars march in cohesive bands to green vegetation. The adults have fully developed long wings and can migrate long distances to grain fields and vegetable crops. When egg laying begins, migration ceases. If the previous egg bed is a short distance from the feeding ground, the males remain on the enlarged egg bed and the females fly back and forth. If the previous egg bed is a long distance from the new feeding ground, a grass sod area near the feeding ground will be used during the outbreak. The outbreak densities increase and remain high for 2 or 3 years, then the population crashes as a result of high or total mortality over the expanded distribution area. Between outbreaks, clearwinged grasshoppers survive on rangeland habitats.

This summary life history of the clearwinged grasshopper was based primarily from the work of Pfadt 1994 with additional information from Watts et al. 1989, Belovsky et al. 1990, and Carruthers et al. 1992.

Life History of the spottedwinged grasshopper

Cordillacris occipitalis (Thomas) (*Cor occ*), the spottedwinged grasshopper, is a serious dominant pest on rangelands, primarily in the mixed grass prairie with sandy loam soils and it can be injurious to grassland ecosystems because it is able to consume substantial quantities of leaves from young native grass tillers prior to the 3.5 new leaf stage. The spottedwinged grasshopper has wide distribution in western North America and it inhabits the rangelands of the Northern Plains. It is a member of the Gomphocerinae subfamily of slantfaced grasshoppers. The adults are small sized grasshoppers. Live weight of the males average 101 mg and the females average 224 mg. Body length of the males is 0.65 to 0.73 in (16.5 to 18.5 mm) and the females is 0.83 to 0.93 in (21.0 to 23.5 mm).

The hatching period is with the early group starting about mid May and lasting 4 weeks. The nymphs develop through 5 instar stages in 36 to 41 days. The fledgling adults require a period of 1 to 2 weeks for growth and maturation after they appear. The males court the females with an intraspecific stridulation song and the male also sends visual signals by raising and lowering his antennae and tipping his hind legs. Females require a period for egg development after mating. Gravid females deposit 2 to 3 eggs per clutch in a straight cylinder shaped pod that is 0.38 in (9.5 mm) long and 0.13 in (3.2 mm) in diameter placed vertically at a shallow depth of 0.5 in (12.7 mm) into bare ground. The eggs begin embryonic growth in the summer of deposition, continue until stage 19 (50%), then enter diapause; the following spring, the embryos complete development to stage 27 and emerge.

The spottedwinged grasshopper is graminivorous and feeds on the green leaves of grasses and sedges. The main food plants are blue grama, needle and thread, western wheatgrass, sand dropseed, downy brome, threadleaf sedge, and needleleaf sedge. The grasshopper climbs up a leaf blade, turns around head down and chews on the leaf;

sometimes the chewing cuts through the leaf and parts fall to the ground. Only rarely do they eat from a horizontal position on the ground, by holding a cut leaf with the front tarsi and consume all of the leaf. They rarely consume small amounts of forbs, dropped leaves, and arthropods parts. This grasshopper does not eat litter.

The adults have long wings and can make lengthy flights. During typical light densities of 0.2 to 0.5/yard² (0.24 to 0.6/m²), the adults remain in the same area that they hatched. They spend part of the day on the ground and part in vegetation. At night, they rest either on vegetation or on the ground. After sunrise and before sunset, they bask by resting with their side exposed to the rays of the sun and by hugging the ground. They perform normal activities of mating, egg laying, feeding, and pottering while the air temperatures are from 70° to 82°F (21° to 28° C). The percent time engaged in daily activities was 81.0% basking, 9.1% pottering, and 9.8% feeding. During the afternoons when the soil temperatures rise above 120° F (49° C), individuals climb small shrubs, like fringed sagebrush, and rest head up in the shade 2 to 8 inches (5.1 to 20.3 cm) above the ground and reduce their body temperature through evaporative cooling by hyperventilation.

Populations of the spottedwinged grasshopper can increase as the dominant species on rangeland with sandy loam soils. The population increases gradually at 2 fold annually for 3 years, and then increases 3 to 4 fold the following year at outbreak numbers of 20/yard² (24/m²). The other members of the outbreak assemblage increase at parallel rates. Densities of whitewiskered reach 9/yard² (10.8/m²), bigheaded reach 7/yard² (8.4/m²), and striped reach 7/yard² (8.4/m²).

This summary life history of the spottedwinged grasshopper was based primarily from the work of Pfadt 1994 with additional information from Mulkern et al. 1969, Watts et al. 1989, Carruthers et al. 1992, and Jech 1996.

Life History of the dusky grasshopper

Encyrtolophus costalis (Scudder) (Encyrtos), the dusky grasshopper, is usually considered to be a subdominant pest on rangelands and, thus, its biology has not been studied intensively, however, it has considerable abundance in the northern mixed grass prairie where it has been associated with a local outbreak in western North Dakota and it has had high population densities in Saskatchewan, and it has been considered to be a pest on alfalfa and winter wheat croplands. The dusky grasshopper has wide distribution in the central region of North America and it inhabits the rangelands of the Northern Plains. It is a member of the Oedipodinae subfamily of bandwinged grasshoppers. The adults are medium sized grasshoppers. Live weight of the males average 168 mg and the females average 468 mg. Body length of the males is 0.59 to 0.73 in (15.0 to 18.5 mm) and the females is 0.85 to 1.0 in (21.5 to 25.5 mm).

The hatching period is with the intermediate group starting about early to mid June and lasting 6 to 8 weeks. The nymphs develop through 5 instar stages over a relatively long period from 56 to 66 days. The adults appear between 8 and 14 August in the Northern Plains. Fledgling adults require a period of 2 to 3 weeks for growth and maturation. Males court the females with an intraspecific stridulation song. A receptive female lowers the hind femur closest to the male and turns her genitalia toward the courting male. Females require a period for egg development after mating. Gravid females deposit 14 to 20 eggs per clutch in a pod that is 0.75 in (19.1 mm) long and slightly curved placed into bare ground, preferably of clay soils, interspersed among native grasses. Little is known about embryo development. The eggs begin embryonic growth in the summer of deposition and continue development until they enter diapause; the following spring, the embryos complete development to stage 27 and emerge.

The dusky grasshopper is graminivorous and feeds on native grasses and sedges. The main food plants are western wheatgrass and needleleaf sedge, and they also feed on northern wheatgrass, needle and thread, green needlegrass, and blue grama. On occasions, they move into cropland and eat alfalfa, winter wheat, and some forbs. The adults feed on

grass leaves by climbing onto a leaf head up beginning halfway up the leaf, cuts through it, holds onto the cut section with the front tarsi, consumes it to the dry tip, and drops the tip; or by consuming leaves of short grasses from the horizontal position on the ground, cutting through the leaf and eating the cut section to the dry tip. They appear to be thrifty feeders; they consume the entire green portion of each leaf cut from a plant.

The adults have fully developed long wings, strong thoracic muscles, and are able to disperse and migrate by flight. During typical low densities, the adults remain in the same area that they hatched. The dusky grasshopper is geophilous and spends almost all of the time on the ground. After sunrise and before sunset, they bask on bare ground by turning a side perpendicular to the rays of the sun. After 2 to 3 hours of basking, they become active and perform normal feeding, walking, and sometimes flying while the ground temperatures range from 76° to 120°F (24° to 49° C) and air temperatures are 66° to 79°F (19° to 26° C). During the afternoons when the soil temperatures rise to 125° F (52° C) and higher, the grasshoppers avoid overheating by moving into partial or full shade, climbing on grass 1 inch (2.5 cm) above the ground and face the sun to expose the least body surface.

Populations of the dusky grasshopper are usually low with around 2.5 adults/yard² (3.0/m²). When the species inhabits rangeland areas of fine sandy loam, the populations remain subdominant at around 0.1 to 1.0 adults/yard² (0.12 to 1.2/m²). Under more favorable conditions in rangeland sites of heavy clay soil with wheatgrasses and needlegrasses, the populations increase to densities of 10 to 12 adults/yard² (12 to 14.4/m²) and remain at high dominant levels for 2 or more years. Population declines have been attributed to decreased soil temperatures that resulted from vegetation shading. These unfavorable conditions delayed the development and maturation of the dusky grasshopper and decreased egg production.

This summary life history of the dusky grasshopper was based primarily from the work of Pfadt 1994 with additional information from Mulkern et al. 1969, Watts et al. 1989, and Onsager 2000.

Life History of the velvetstriped grasshopper

Eritettix simplex (Scudder) (Eri sim), the velvetstriped grasshopper, over winters in the nymphal stage and is seldom abundant on most rangelands, however, it has been associated with outbreaks in eastern North Dakota on sand prairie and it can be injurious to grassland ecosystems because it is able to consume substantial quantities of leaves from young native grass tillers prior to the 3.5 new leaf stage. The velvetstriped grasshopper has a wide distribution in the central region of North America and it inhabits the rangelands of the Northern Plains; it has a smaller distribution center along the eastern slopes of the Appalachian Mountains. It prefers grassland habitat of short and mid grasses at a diminished condition with some weeds. It is a member of the Gomphocerinae subfamily of slantfaced grasshoppers. The adults are medium sized grasshoppers. Live weight of the males average 108 mg and the females average 269 mg. Body length of the males is 0.59 to 0.65 in (15.0 to 16.5 mm) and the females is 0.87 to 0.93 in (22.0 to 23.5 mm).

The hatching period is with the very late group, as are all grasshoppers that overwinter as a nymph, starting about mid to late July and lasting 4 weeks. The nymphs develop and grow for about 100 days. Nymphs at the third and fourth instar stages overwinter under the cover of ground litter. Nymphs are cold tolerant and can survive temperatures as low as 5° F (-15° C). The following spring, as temperatures increase and daily photoperiods lengthen, the nymphs crawl out from their winter cover and complete development in April and May. The fledgling adults require some time for growth and maturation. Males follow females and, when near, the male rocks from side to side and courts the females with an intraspecific stridulation song. Females require a period for egg development after mating. Gravid females oviposit into bare ground. A clutch contains about 18 eggs in a fragile pod that is 1 in (25.4 mm) long and 0.13 in (3.2 mm) in diameter. There have been no studies on embryo development. The embryos require favorable incubation temperatures to develop completely to stage 27 and hatch during the same summer they were laid.

The velvetstriped grasshopper is graminivorous and feeds on grasses and sedges. During the summer and fall, the new generation of nymphs feed almost exclusively on blue grama. The next spring, the nymphs feed on cool season grasses and sedges. The adults preferentially feed on blue grama. Velvetstriped grasshoppers feed on grass leaves from the ground raising itself up by its hind legs beginning about 1 inch (2.5 cm) above ground level or by climbing onto the grass plant beginning near the middle. They cut narrow leaves, hold onto the cut section with their front tarsi, and consume the cut leaf to the dry tip, or they feed on wide leaves to the midrib leaving the other half of the leaf attached and standing. Feeding is usually conducted with head up and body vertical or diagonal.

The adults have fully developed wings and are able to disperse by flight. During typical low densities, the adults remain in the same area that they hatched. The velvetstriped grasshopper is geophilous and spends most of the time on the ground. The nymphs are exposed to cold temperatures during the fall and spring and require favorable microhabitat that allows regulation of body temperatures at tolerable levels. During the winter, the hibernating nymphs require protection under ground litter that insulates their bodies from cold air temperatures. Nymphs crawl out from shelter when soil temperatures reach about 60° F (15.6° C) and bask with their body perpendicular to the rays of the sun or by exposing their backs to the rays of the sun. Adults bask on the ground similarly as nymphs. Adults begin feeding when soil temperatures reach 80° F (27° C) and air temperatures at 55° to 60° F (13° to 16° C):

Populations of the velvetstriped grasshopper are usually low on most rangeland habitat with around 0.1 to 0.6 adults/yard² (0.12 to 0.72/m²). Populations have reached dominant pest status on preferred sand prairie habitats in southeastern North Dakota with densities at 6.7 adults/yard² (8.0/m²).

This summary life history of the velvetstriped grasshopper was based primarily from the work of Pfadt 1994 with additional information from Mulkern et al. 1969 and Watts et al. 1989.

Life History of the two-striped grasshopper

Melanoplus bivittatus (Say) (Mel biv), the two-striped grasshopper, is a major pest on rangelands, primarily in tall grass and wet meadow vegetation and is a major pest on croplands. It has adapted to cropland agricultural practices and has taken advantage of the abundant nutritious weedy plants associated with cropland augmenting this grasshoppers capacity to damage or destroy most types of crops during outbreaks. It prefers deteriorated pastures invaded with weeds. The two-striped grasshopper has extensive distribution across North America and it inhabits the rangelands of the Northern Plains that have lush herbaceous vegetation. It is a member of the Melanoplinea subfamily of the spurthroated grasshoppers. The adults are large sized grasshoppers. Live weight of the males average 549 mg and the females average 1,086 mg. Body length of the males is 1.1 to 1.2 in (28.0 to 30.0 mm) and the females is 1.4 to 1.6 in (36.0 to 41.0 mm).

The hatching period is with the early group starting about mid to late May and lasting 4 to 6 weeks. The nymphs develop through 5 instar stages in about 40 days but may be present in the habitat for as long as 75 days because of the extended hatch period. The fledgling males require a period for growth and maturation after they appear. Females have preoviposition period of 1 to 2 weeks between fledging and ovipositing the first clutch of eggs. A male stealthily approaches a female, leaps and mounts the female, then the male performs a courtship ritual by shaking his hind femurs for 3 or 4 seconds. Gravid females deposit 50 to 108 eggs per clutch in a large curved delicate pod that is 1.13 to 1.5 in (28.6 to 38.1 mm) long and 0.25 in (6.4 mm) in diameter placed into bare ground near roots of grasses or weeds. Grasshoppers that have migrated to cropland do not have to travel back to rangeland to deposit the eggs. The females move to poorly managed cropland borders with south facing slopes and compact drift soil. The egg clutches are deposited near roots of grasses or weeds. The eggs begin embryonic growth in the summer of deposition, continue until stage 20 or 24 (60% to 80%), then enter diapause; the following spring, the embryos complete development to stage 27 and emerge.

The two-striped grasshopper is polyphagous and feeds on many kinds of forbs, grasses, and crops.

Nymph diets that contain weeds associated with cropland promote high survival, fast growth, and heavy weights. A two-striped grasshopper feeding on cropland foliage wastes 6 times as much vegetation as it consumes. Generally, they climb in or on the plant to feed.

The grasshoppers that hatch on cropland borders appear to be more successful than grasshoppers that hatch on rangeland. They spend part of the day on the ground and part of the day on vegetation and they spend the nights resting halfway up on vegetation. After sunrise and before sunset, they bask on the ground by resting with their side exposed to the rays of the sun. During the day when soil temperatures are 70° F (21° C) or greater, adults perform normal activities on the ground. When the soil temperatures rise to 112° F (44° C), individuals seek shade and climb up on vegetation stems to reduce their body temperature through evaporative cooling by hyperventilation. *Melanoplus bivittatus* is one of the preferred hosts of two endoparasite flies, *Acridomyia canadensis* (anthomyiid fly) and *Acemyia tibialis* (tachinid fly); both fly larvae consume the grasshopper from inside.

Populations of two-striped grasshoppers increase slowly for 3 or more years in assemblages with the differential grasshopper. Nymphs at the third instar and older move in bands. Adults at high densities develop longer wings and slimmer bodies and can fly long distances in swarms to search for green food and can damage small grains, alfalfa, corn, vegetables, fruit, and shelterbelt trees. During the outbreaks of high densities, the grasshoppers do not need to return to rangeland but can successfully hatch high numbers for 2 to 3 years from cropland border areas that have south facing slopes with compact drift soil. Outbreak assemblages usually comprise differential grasshoppers at about equal numbers. The two-striped grasshopper was one of the major pest species during the severe outbreak of the 1930's in North and South Dakota.

This summary life history of the two-striped grasshopper was based primarily from the work of Pfadt 1994 with additional information from Mulkern et al. 1969, Watts et al. 1989, Belovsky et al. 1990, and Carruthers et al. 1992.

Life History of the pasture grasshopper

Melanoplus confusus (Scudder) (Mel con), the pasture grasshopper, is usually a common subdominant pest on rangelands, however, it has been associated with local outbreaks in Saskatchewan, Wyoming, and North Dakota on rangelands and croplands, and it can be injurious to grassland ecosystems because it is able to consume substantial quantities of leaves from young native grass tillers prior to the 3.5 new leaf stage. The pasture grasshopper has wide distribution across eastern and central North America and it inhabits the rangelands of the Northern Plains. It is a member of the Melanoplineae subfamily of spurthroated grasshoppers. The adults are medium sized grasshoppers. Body length of the males is 0.71 to 0.75 in (18.0 to 19.0 mm) and the females is 0.91 to 0.94 in (23.0 to 24.0 mm).

The hatching period is with the very early group starting about late April to early May and lasting 4 weeks. The nymphs develop through 5 instar stages in about 40 to 46 days. The fledgling adults require a period for growth and maturation after they appear. The male courter approaches a female, when close, he pounces on her and attaches their genitalia. Females require a period for egg

development after mating. Gravid females deposit 10 to 15 eggs per clutch in bare ground near buffalograss, blue grama, or other short grass. The eggs are laid deep into the soil about 1.25 in (3.2cm). The pod is 1.0 to 1.13 in (25.4 to 28.6 mm) long and 0.13 in (3.2 mm) in diameter. On top of the eggs is a plug of dried froth 0.5 to 0.75 in (12.7 to 19.1 mm) long. The eggs begin embryonic growth in the summer of deposition and continue until they enter diapause; the following spring, the embryos complete development and emerge very early.

The pasture grasshopper is polyphagous and feeds on both grasses and forbs, and they will consume cereal grains. At typical low densities, the adults remain in the same area that they hatched. They are diurnal, active during the day and inactive at night. The population numbers increase from low densities of less than 0.1 adult/yard² to 2.7 adults /yard² (0.12/m² to 3.2/m²). The pasture grasshopper remains subdominant in assemblages that include the clubhorned grasshopper when they increase to outbreak levels.

This summary life history of the pasture grasshopper was based primarily from the work of Pfadt 1994 with additional information from Mulkern et al. 1969.

Life History of the differential grasshopper

Melanoplus differentialis (Thomas) (Mel dif), the differential grasshopper, is a major pest on rangelands, primarily on tall grass and wet meadow vegetation and it is a severe destructive pest on croplands and adjacent unmanaged grass areas. It has adapted to cropland agricultural practices and has taken advantage of the abundant nutritious weedy plants associated with cropland augmenting this grasshoppers capacity to damage or destroy most types of crops during outbreaks. It prefers deteriorated pastures with weedy patches. The differential grasshopper has wide distribution across the United States and Mexico and it inhabits the rangelands of the Northern Plains, mostly in moist weedy grassland meadows with taller vegetation. It is a member of the Melanoplineae subfamily of the spurthroated grasshoppers. The adults are large sized grasshoppers. Body length of the males is 0.87 to 1.26 in (22.0 to 32.0 mm) and the females is 1.18 to 1.3 in (30.0 to 33.0 mm).

The hatching period is with the intermediate group starting about mid June and lasting 2 weeks. The nymphs develop rapidly through 5 instar stages in about 32 days. The fledgling adults require a period of several weeks for growth and maturation after they appear. Males and females form mating pairs. Females require a period for egg development after mating. Gravid females deposit 45 to 194 eggs per clutch in a large curved fragile pod that is 1.5 in (38 mm) long and 0.25 in (6.4 mm) in diameter placed in a vertical position in bare ground near roots of grasses or weeds in land with grass sod. The eggs begin embryonic growth in the summer of deposition, continue until development of 54% (between stages 19 and 20), then enter diapause; the following spring, the embryos complete development to stage 27 and emerge.

The differential grasshopper is polyphagous and feeds on many kinds of grasses, forbs, and crops. Diets that contain mainly weedy forbs associated with cropland promote faster growth, larger size, and more eggs.

The grasshoppers that hatch on cropland borders appear to be more successful than grasshoppers that hatch on rangeland. They spend part of the day on the ground and part of the day on vegetation and they spend the nights resting high up on vegetation. After sunrise and before sunset, they bask on the ground by resting with their side exposed to the rays of the sun. During the day while soil temperatures range from 70° F to less than 112° F (21° to 44° C), the adults perform normal activities of mating, laying eggs, and feeding. When the soil temperatures rise to 112° F (44° C), individuals seek shade and climb up on vegetation stems to reduce their body temperature through evaporation cooling by hyperventilation or they may rise in flight. Populations of differential grasshopper can increase to outbreak densities in 1 to 2 years. Nymphs in the third instar and older at high population densities move in the same direction as cohesive bands. Adults at high densities develop longer wings and slimmer bodies and can fly long distances in search for green food. They can damage crops of small grains, corn, soybeans, sunflowers, vegetables, and fruit trees. During the outbreaks of high densities, the grasshoppers do not need to return to rangeland, but can successfully hatch high numbers from unmanaged cropland borders with grass sod. Outbreak assemblages usually comprise two-striped grasshoppers at about equal numbers. The differential grasshopper was one of the major pest species during the severe outbreak of the 1930's in North and South Dakota.

This summary life history of the differential grasshopper was based primarily from the work of Pfadt 1994 with additional information from Mulkern et al. 1969, Watts et al. 1989, and Carruthers et al. 1992.

Life History of the redlegged grasshopper

Melanoplus femurrubrum (De Geer) (Mel fem), the redlegged grasshopper, is a wasteful dominant pest on rangelands primarily in tall grass and meadow vegetation, it is a pest on crested wheatgrass pastures, and it is an extremely destructive major pest on croplands. It has adapted to cropland agricultural practices and the associated unmanged weedy areas and can damage or destroy most types of crops during outbreaks. It prefers deteriorated grassland pastures that have been invaded by weedy plants. The redlegged grasshopper has extensive distribution across North America and is the most abundant grasshopper species in eastern United States and Canada. It inhabits the rangelands of the Northern Plains, mostly in moist weedy grassland meadows with taller vegetation. It is a member of the Melanoplineae subfamily of the spurthroated grasshoppers. The adults are medium sized grasshoppers. Live weight of the males average 289 mg and the females average 389 mg. Body length of the males is 0.69 to 0.91 in (17.5 to 23.0 mm) and the females is 0.94 to 1.1 in (24.0 to 28.0 mm).

The hatching period is with the intermediate group starting about early June and lasting 7 to 8 weeks. The nymphs develop through 5 instar stages in about 40 days. The fledgling males require a period of growth and maturation after they appear. Females have a preoviposition period of 2 weeks or more between fledging and ovipositing. Males and females form mating pairs. Gravid females deposit 20 to 26 eggs per clutch in a distinctly curved pod that is 0.75 to 1.0 in (19.1 to 25.4 mm) long and 0.13 to 0.19 in (3.2 to 4.8 mm) in diameter placed into sod soil with widely variable exposure to sun light. The eggs begin embryonic growth in the summer of deposition and continue until they enter diapause; the following spring, the embryos complete development and emerge.

The redlegged grasshopper is polyphagous and feeds on many kinds of forbs, grasses, and crops. Primarily it feeds on the plants that are available and is known to consume birdsfoot trefoil, white and yellow sweetclover, milkvetches, dandelion, goldenrod, kochia, western ragweed, kentucky bluegrass, smooth brome, japanese brome, timothy, and reed canarygrass. Generally, they climb in or on the plant to feed. The redlegged grasshopper ingests 25% of the foliage removed from food plants and wastes 75%.

Low density periods last from 2 to over 5 years. The adults remain in the same grassland meadows that they hatched. They are active during the day and roost on grasses and weeds at night.

Populations of the redlegged grasshopper can increase within 1 or 2 years to outbreak densities during periods of reduced rainfall and warm temperatures. During years of drought, the adults develop longer wings, fly more, and make lengthy flights with the migratory grasshopper. During the 2 to 3 years at outbreak densities, the assemblages may include the migratory, twostriped, and differential grasshoppers. Following the severe damage to forage grasses of their hatch site, the adults move to cropland and damage or destroy fields of barley, oat, wheat, soybeans, corn, alfalfa, and vegetable crops. The population densities decrease during periods of normal rainfall and cool spring temperatures.

This summary life history of the redlegged grasshopper was based primarily from the work of Pfadt 1994 with additional information from Mulkern et al. 1969, Belovsky et al. 1990, and Onsager 2000.

Life History of the gladston grasshopper

Melanoplus gladstoni (Scudder) (Mel gla), the gladston grasshopper, is a common codominant pest on rangelands, it has been associated with local outbreaks in the short grass and mixed grass prairies, it is a pest on crested wheatgrass pastures, and it has caused destruction on alfalfa and winter wheat croplands. The gladston grasshopper has wide north south distribution through the central region of North America and it inhabits the rangelands of the Northern Plains, primarily the mixed grass prairie. It is a member of the Melanoplinae subfamily of the spurthroated grasshoppers. The adults are medium sized grasshoppers. Live weight of the males average 446 mg and the females average 509 mg. Body length of the males is 0.75 to 0.89 in (19.0 to 22.5 mm) and the females is 0.79 to 0.99 in (20.1 to 25.2 mm).

The hatching period is with the late group starting about mid to late June and lasting 1 to 2 weeks. The nymphs develop through 5 instar stages in about 42 to 70 days. The adults appear from mid August to mid September. Fledgling adults requires about 8 days for growth and maturation. Males and females form mating pairs. Gravid females deposit 16 to 29 eggs per clutch in curved pod that is 1.0 to 1.13 in (25.4 to 28.6 mm) long placed into bare ground. The pod is laid diagonally at relatively shallow depths between 0.31 to 0.63 in (7.9 to 15.9 mm). The eggs begin embryonic growth in the summer of deposition and continue until they enter diapause; the following spring, the embryos complete development and emerge.

The gladston grasshopper is polyphagous and feeds on numerous forbs, grasses, sedges, and dry litter. Food items from grasshopper crops collected from mixed grass, short grass, and sand prairies have

included 43 species of forbs, 11 grasses, and 2 sedges. Adults feed by climbing onto a forb or grass with head up or they feed from the ground in the horizontal position.

The adults have fully developed long wings and are strong fliers. They are capable of dispersal flights and mass migration. At typical low densities, the adults remain in the same area that they hatched. The gladston grasshopper is geophilous and dwells chiefly on the ground. They spend the night horizontally on bare ground or on litter under canopies of short grasses, usually blue grama. After sunrise and before sunset, they bask on bare ground by turning a side perpendicular to the rays of the sun. After 1 or 2 hours of basking, they become active when soil temperatures range from 59° to 103° F (15° to 39° C) and air temperatures from 59° to 76° F (15° to 24° C). They mate, feed, and walk about on the ground. When temperatures rise above tolerance levels, they cease activity and face the sun or face directly away and stilt. When temperatures continue to increase, they climb vegetation to heights of 4 inches (10.2 cm) or more to reduce their body temperature through evaporative cooling by hyperventilation.

Populations of the gladston grasshopper are usually low at less than 1.0 adult/yard² (1.2/m²). In short grass areas of the mixed grass prairie and in the short grass prairie during outbreaks, gladston grasshopper densities can increase to 4 adult/yard² (4.8/m²) and they usually remain as subdominant members of the assemblage.

This summary life history of the gladston grasshopper was based primarily from the work of Pfadt 1994 with additional information from Mulkern et al. 1969, Carruthers et al. 1992, and Onsager 2000.

Life History of the little spurthroated grasshopper

Melanoplus infantilis (Scudder) (Mel inf), the little spurthroated grasshopper, is an important dominant pest on rangelands, primarily in the northern mixed grass prairie in the United States and in the prairie provinces of Canada north to the aspen parkland. It is a pest on crested wheatgrass pastures, and it can be injurious to grassland ecosystems because it is able to consume substantial quantities of leaves from young native grass tillers prior to the 3.5 new leaf stage. The little spurthroated grasshopper has wide distribution in western North America and it inhabits the rangelands of the Northern Plains. It is a member of the Melanoplineae subfamily of spurthroated grasshoppers. The adults are small sized grasshoppers. Live weight of the males average 157 mg and the females average 236 mg. Body length of the males is 0.65 to 0.67 in (16.5 to 17.0 mm) and the females is 0.63 to 0.74 in (16.0 to 19.0 mm).

The hatching period is with the early group starting about late May to mid June and lasting 3 weeks. The nymphs develop most rapidly through 5 instar stages in 27 to 34 days. The fledgling adults require a period of growth and maturation after they appear. Males and females form mating pairs. Females require a period for egg development after mating. Gravid females deposit 10 to 13 eggs per clutch in a curved pod that is 0.88 to 1.0 in (22.2 to 25.4 mm) long placed in bare soil, sometimes near short grass, at depth of 1.0 in (2.5 cm). The eggs begin embryonic growth in the summer of deposition and continue until they enter diapause; the following spring, the embryos complete development and emerge.

The little spurthroated grasshopper feeds on grasses, sedges, and forbs. The food plants include blue grama, western wheatgrass, needle and thread,

sand dropseed, idaho fescue, parry oatgrass, sandberg bluegrass, threadleaf sedge, needleleaf sedge, scarlet globemallow, woolly plantain, broom snakeweed, fringed sagebrush, dandelion, and milkvetch. They feed from the ground, cut a section of grass leaf from the plant, hold the cut leaf with their front tarsi, and consume the entire leaf section from the cut end to tip. This process continues until they are satiated. They also eat fallen leaf parts from the ground litter.

At typical low densities of 0.1 to 0.5/yd² (0.12 to 0.6/m²), the adults remain in the same area that they hatched. During the inactive night, they roost on the ground or on small shrubs. After sunrise and before sunset, they bask on bare ground or on the crown of blue grama by exposing their side to the rays of the sun. During the day when the soil temperature is 80° F (27° C) or greater and the air temperature is 68° F (20° C) or greater, adults perform normal activities. During the afternoons that soil temperatures rise to 115° F (46° C), individuals climb grass stems and rest vertically head up 2 inches (5.1 cm) above the soil surface to reduce their body temperature through evaporative cooling by hyperventilation.

Population densities of little spurthroated grasshoppers can increase to outbreak levels of 20 to 40/yd² (24 to 48/m²) during favorable conditions. The outbreak assemblages usually include the bigheaded grasshopper and other species. The little spurthroated grasshopper is sometimes the dominant member.

This summary life history of the little spurthroated grasshopper was based primarily from the work of Pfadt 1994 with additional information from Mulkern et al. 1969, Watts et al. 1989, Carruthers et al. 1992, and Onsager 2000.

Life History of the flabellate grasshopper

Melanoplus occidentalis (Thomas) (Mel occ), the flabellate grasshopper, is a frequent codominant pest on rangelands, primarily in the northern mixed grass prairie and it can be injurious to grassland ecosystems because it is able to consume substantial quantities of leaves from young native grass tillers prior to the 3.5 new leaf stage. The flabellate grasshopper has wide distribution in the central region of North America and it inhabits the rangelands of the Northern Plains. It is a member of the Melanoplinae subfamily of spurthroated grasshoppers. The adults are medium sized grasshoppers. Live weight of the males average 280 mg and the females average 567 mg. Body length of the males is 0.76 to 0.83 in (19.2 to 21.0 mm) and the females is 0.87 to 0.94 in (22.0 to 24.0 mm).

The hatching period is with the early group starting about mid May and lasting 3 to 4 weeks. The nymphs develop through 5 instar stages in about 40 to 45 days. The fledgling adults require a period of growth and maturation after they appear. Males and females form mating pairs. Females require a period for egg development after mating. Gravid females deposit 8 to 10 eggs per clutch in a curved pod that is 1.0 in (25.4 mm) long and 0.13 in (3.2 mm) in diameter placed into bare ground at a depth of about 1.0 in (2.5 cm). The eggs begin embryonic growth in the summer of deposition and continue until they enter diapause; the following spring, the embryos complete development and emerge.

The flabellate grasshopper feeds chiefly on forb leaves but also consumes substantial quantities

of grasses and dry litter. The main food plants are scarlet globemallow, wildbuckwheat, milkvetch, blue grama, needle and thread, western wheatgrass, kentucky bluegrass, and needleleaf sedge. Adults feed by climbing onto a forb or grass plant or they feed from the ground.

The adults have fully developed long wings and are strong fliers. They are capable of dispersal flights and appears likely to be able to migrate in mass. At typical low densities, the adults remain in the same area that they hatched. The flabellate grasshopper is geophilous and spends most of the time on the ground. At night, both nymphs and adults rest horizontally on bare ground. After sunrise and before sunset, they bask on bare ground by turning a side perpendicular to the rays of the sun. After about 2 hours of basking, they become active and perform normal mating, egg laying, feeding, and pottering activities while the ground temperatures range from 90° to 100° F (32° to 38° C) and air temperature are around 70° F (21° C). During the afternoons when soil temperatures rise to 130° F (54° C) and air temperatures rise above 90° F (32° C), adults climb small shrubs to heights of 3 to 6 inches (7.6 to 15.2 cm) and rest in the shade.

Populations of flabellate grasshopper are usually low at around 0.1 adult/yard² (0.12/m²) but have increased to 7.3 adult/yard² (8.8/m²) as part of multispecies outbreak assemblages.

This summary life history of the flabellate grasshopper was based primarily from the work of Pfadt 1994 with additional information from Mulkern et al. 1969.

Life History of the packard grasshopper

Melanoplus packardii (Scudder) (Mel pac), the packard grasshopper, is a serious codominant pest on rangelands, primarily in the northern mixed grass prairie, preferring vegetation on loamy or sandy loam soils with scant grass canopy cover. It is also an important pest on croplands and adjacent unmanaged grass areas. It has adapted to cropland agricultural practices and can damage many types of crops during outbreaks. The packard grasshopper has wide distribution in western North America and it inhabits the rangelands of the Northern Plains. It is a member of the Melanoplineae subfamily of spurthroated grasshoppers. The adults are large sized grasshoppers. Live weight of the males average 571 mg and the females average 639 mg. Body length of the males is 1.06 to 1.26 in (27.0 to 32.0 mm) and the females is 1.26 to 1.40 in (32.0 to 35.5 mm).

The hatching period is with the early group starting about mid May to early June and lasting 5 weeks. Nymphs develop through 5 instar stages in 47 to 63 days. The fledgling adult males require a period for growth and maturation after they appear in early July. Females have a preoviposition period of 3 weeks between fledging and ovipositing. Males and females form mating pairs. Gravid females deposit 16 to 29 eggs per clutch in a slightly curved pod that is 1.25 in (3.18 mm) long and 0.19 in (4.8 mm) in diameter placed deep in bare ground. The eggs begin embryonic growth in the summer of deposition, continue until a late stage with greatly advanced development, then enter diapause; the following spring, the embryos complete development of the last few stages and emerge early.

The packard grasshopper is polyphagous and feeds on both forbs and grasses, and they consume numerous types of crops. The food plants include scurfpea, milkvetch, woolly loco, prickly lettuce, western ragweed, sweetclover, blue grama, sand dropseed, needle and thread, and smooth brome grass. They feed from the ground, reach up, and feed on leaves.

At typical low densities of 0.1 to 0.4/yard² (0.12 to 0.48/m²), most adults remain in the same area that they hatched. The packard grasshopper is geophilous and spends most of the time on the ground. At night, they rest horizontally on bare ground or on litter. After sunrise and before sunset, they bask on bare ground with their side or back exposed to the rays of the sun. During the day when soil temperatures are 80° F (27° C) or greater and air temperatures are 70° F (21° C) or greater, adults perform normal activities. When the soil temperatures rise above 120° F (49° C) and air temperatures are above 90° F (32° C), individuals climb vegetation and rest vertically head up 2 to 10 inches (5.1 to 25.4 cm) above the ground to reduce their body temperature through evaporative cooling by hyperventilation. *Melanoplus packardii* is one of the preferred hosts of the endoparasite *Acridomyia canadensis* (anthomyiid fly); the fly larvae consumes the grasshopper from inside.

Populations of the packard grasshopper can increase to outbreak densities. The assemblages usually include the migratory grasshopper as the dominant, the two-striped grasshopper as the second, and the packard grasshopper as the third. All three species have long wings and are strong fliers. The adults move to cropland and damage or destroy fields of winter wheat, fall rye, barley, alfalfa, and sunflowers. During the outbreak periods, these adapted grasshoppers perform well in the unmanaged grass and weed areas near cropland fields, feeding on nutritious weeds and field crops, and laying eggs in favorable sites of drift soil with south facing slopes.

This summary life history of the packard grasshopper was based primarily from the work of Pfadt 1994 with additional information from Mulkern et al. 1969, Carruthers et al. 1992, and Hostetter 1994.

Life History of the migratory grasshopper

Melanoplus sanguinipes (Fabricius) (Melanoplinae), the migratory grasshopper, is the most damaging and the most widely distributed dominant pest on rangelands and crested wheatgrass pastures. It has successfully adapted to cropland agricultural practices and has caused more damage than any other grasshopper species. It prefers deteriorated grassland pastures invaded with weeds. The migratory grasshopper has extensive distribution across North America and it inhabits the rangelands of the Northern Plains. It is a member of the Melanoplinae subfamily of spurthroated grasshoppers. The adults are medium sized grasshoppers. Live weight of the males average 338 mg and the females average 442 mg. Body length of the males is 0.79 to 1.02 in (20.0 to 26.0 mm) and the females is 0.79 to 1.14 in (20.0 to 29.0 mm).

The hatching period is with the early group starting mid to late May and lasting 3 to 6 weeks depending on soil temperature, soil type, and amount of shading from vegetation. The male nymphs develop through 5 instar stages and the female nymphs usually develop through 6 instar stages in 35 to 55 days depending on air temperatures. The fledgling males require a period for growth and maturation after they appear. The females have a preoviposition period of 2 to 3 weeks between fledging and ovipositing the first clutch. The males court the females by waving his antennae and vibrating his hind femurs. About 6 days after they mate, gravid females deposit 18 to 24 eggs per clutch in a curved pod that is 1.0 in (25.4 mm) long and 0.13 in (3.2 mm) in diameter placed vertically into bare soil with the eggs oriented diagonally among the roots of blue grama or other short grass. On cropland, the egg pods are deposited around the base of crop or weedy plants. The eggs begin embryonic growth in the summer of deposition, continue development to stage 24 (80%) after 422 DD (degree days) of heat, then enter diapause until low soil temperatures during winter break diapause; the following spring, the embryos resume development at the base soil temperature of 50° F (10° C) and complete development to stage 27 after an additional 105 DD (degree day) of heat and emerge. Complete embryonic development of the eggs during the summer and spring requires a total of 527 DD day-degrees of heat above threshold of 50° F (10° C) soil temperature.

The migratory grasshopper is polyphagous and feeds on many kinds of plants both forbs and grasses, and they consume numerous types of crops.

The food plants include dandelion, mustards, pepperweed, western ragweed, blue grama, western wheatgrass, sandberg bluegrass, sand dropseed, downy brome, kentucky bluegrass, squirreltail, and stinkgrass. Generally, they climb in or on the plant to feed. They also ingest dry plant litter and cattle manure from the ground.

At typical low densities of 0.1 to 3.0/yard² (0.12 to 3.6/m²), the adults remain on the same rangeland area that they hatched. They are diurnal, active during the day and inactive at night. The migratory grasshopper is geophilous and spends most of the time on the ground. During the night, nymphs and adults rest horizontally on the ground. After sunrise and before sunset, they bask on the ground or on vegetation by exposing their side to the rays of the sun. During the day, adults perform normal activities of mating, laying eggs, feeding, and pottering (walking around aimlessly). As soil temperatures rise, grasshoppers on bare ground stilt. When the soil temperatures rise above 130° F (54° C), individuals climb vegetation, often western wheatgrass, to heights of 2 to 8 inches (5.1 to 20.3 cm) and reduce their body temperature through evaporative cooling by hyperventilation. *Melanoplus sanguinipes* is one of the preferred hosts of the endoparasite *Acemyia tibialis* (tachinid fly); the fly larvae consumes the grasshopper from inside.

The migratory grasshopper has a great capacity to increase its population numbers. A low density at 3/yard² (3.6/m²) can reproduce exponentially in a favorable year so that the next year, the population reaches outbreak densities of 30/yard² (36/m²). Over a period of several favorable years, densities can reach enormous levels of 60 to 140/yard² (72 to 168/m²). The older nymphs travel together in a band at rates of around 0.1 mile per hour (0.16 km/hr) and move distances of less than 5 miles (8 km) to as far as 10 miles (16 km). Adults are highly migratory during their prereproductive stage. Swarming occurs on clear days and move with the wind at speeds of 10 to 12 miles per hour (16 to 19 km/hr). During the afternoon, they alight to feed and rest. At high densities, they can nearly destroy fields of wheat, barley, oat, corn, alfalfa, clover, vegetables, and ornamental plants. They also attack vines, bushes, and trees, feeding on foliage, fruit, and bark. The high density outbreaks can last 2 to 3 years. The large populations develop on the unmanaged grass and weedy areas near cropland fields. The females deposit the egg pods near roots of weedy plants in wind blown drift soil with south facing slopes. The outbreak assemblages are usually dominated by the migratory grasshopper and may include the

twostriped, the differential, the redlegged, and/or the packard grasshoppers.

This summary life history of the migratory grasshopper was based primarily from the work of Pfadt 1994 with additional information from Mulkern et al. 1969, Watts et al. 1989, Belovsky et al. 1990, Carruthers et al. 1992, Hostetter 1994, and Onsager 2000.

Life History of the bluelegged grasshopper

Metator pardalinus (Saussure) (Met par), the bluelegged grasshopper, is an important codominant pest on rangelands, primarily in the northern mixed grass prairie, preferentially on areas dominant by western wheatgrass on clay soils. The bluelegged grasshopper has wide distribution in central North America and it inhabits the rangelands of the Northern Plains. It is a member of the Oedipodinae subfamily of bandwinged grasshoppers. The adults are large sized grasshoppers. Live weight of the males average 294 mg and the females average 828 mg. Body length of the males is 0.87 to 0.98 in (22.0 to 25.0 mm) and the females is 1.18 to 1.34 in (30.0 to 34.0 mm).

The hatching period is with the intermediate group starting about early June and lasting as short as 1 week. The nymphs develop through 5 instar stages in about 36 days. The fledgling adults require a period for growth and maturation after they appear. Males and females form mating pairs. Courtship of the bluelegged grasshopper has not been recorded. Females require a period for egg development after mating. Gravid females deposit 14 large eggs per clutch in a pod placed 1 to 2 inches (2.5 to 5.1 cm) deep into bare ground or ground covered with litter among short grasses. The eggs begin embryonic growth in the summer of deposition, development continues to an undetermined stage, then enter diapause; the following spring, the embryos complete development to stages 27 and emerge.

The bluelegged grasshopper is graminivorous and feeds almost exclusively on grasses and sedges. The preferred food plants are western wheatgrass and needleleaf sedge, but will also eat bluebunch wheatgrass, needle and thread, green needlegrass, sand dropseed, prairie junegrass, and blue grama. They also will consume small amounts of lichen, green and dry grass litter, and dry cattle dung. The grasshopper climbs the stem of western wheatgrass and cuts a 3 to 4 inch (7.6 to 10.2 cm) section of leaf, which falls to the ground. The grasshopper drops to the ground and recovers the cut

leaf section. Holding the cut leaf with its front tarsi, the grasshopper devours the leaf from one end to the other. The grasshopper will consume any green leaf lying on the ground or any low attached leaf that can be reached from the ground.

Typical low densities are 1 to 4/yard² (1.2 to 4.8/m²). The adults have long wings and could disperse to new areas, however, the majority of adults remain in the same area that they hatched. The bluelegged grasshopper is geophilous and spends most of the day and all of the night on the ground. At night, both nymphs and adults sit on the bare ground under canopies of grass or some sit unprotected by grass. After sunrise and before sunset, they bask by resting on bare ground with their side exposed to the rays of the sun. During the day when soil temperatures are 80° F (27° C) or greater and air temperatures are 67° F (19° C) or greater, the adults perform normal activities of seeking a mate, feeding, and walking around. On afternoons when the soil temperatures rise to 120° F (49° C), individuals rest horizontally on the ground in shade of vegetation or they may climb on grass stems to a height of 2 inches (5.1 cm) to reduce their body temperature through evaporative cooling by hyperventilation. Some adults may move into the crowns of grasses and rest diagonally on leaves in the shade. *Metator pardalinus* is one of the preferred hosts of the endoparasite *Neorhynchocephalus sackenii* (tangleveined fly); the fly larva consumes the grasshopper from inside.

Populations of the bluelegged grasshopper can increase to high densities of 10/yard² (12/m²) in mesic habitats dominated by western wheatgrass. During outbreak populations, the bluelegged grasshopper is codominant with the bigheaded grasshopper.

This summary life history of the bluelegged grasshopper was based primarily from the work of Pfadt 1994 with additional information from Mulkern et al. 1969, Carruthers et al. 1992, and Hostetter 1994.

Life History of the obscure grasshopper

Opeia obscura (Thomas) (Ope obs), the obscure grasshopper, is an important codominant pest on rangelands, primarily in the short grass vegetation dominated by blue grama. It has been associated with a local outbreak in western North Dakota. The obscure grasshopper has wide distribution in western North America and it inhabits the rangelands of the Northern Plains. It prefers grassland habitat with short grass of blue grama or buffalograss, or heavily grazed mid and tall grasses. It is a member of the Gomphocerinae subfamily of slantfaced grasshoppers. The adults are small sized grasshoppers. Live weight of the males average 66 mg and the females average 143 mg. Body length of the males is 0.53 to 0.59 in (13.5 to 15.0 mm) and the females is 0.71 to 0.78 in (18.0 to 19.7 mm).

The hatching period is with the late group starting about early to late June and lasting 2 to 4 weeks. The nymphs develop through 5 instar stages in about 36 to 50 days. The adults appear from late July to early August. Fledgling adults require a period for growth and maturation after they appear. Males and females form mating pairs. Females require a period for egg development after mating. Gravid females deposit 8 to 10 small eggs per clutch in a pod that is 0.88 in (22.2 mm) long placed into bare ground at a relatively deep depth of 0.63 to 0.88 in (15.9 to 22.2 mm). The eggs begin embryonic growth in the summer of deposition and continue until they enter diapause; the following spring, the embryos complete development and emerge.

The obscure grasshopper is graminivorous and feeds on grasses. It prefers blue grama. The grasshopper consumes the green portion of grass leaves. It sits vertically, head up, on a blue grama leaf, cuts it near the middle, holds the cut portion with the front tarsi, and devours the cut leaf to the dry tip, or it feeds on a blue grama leaf in the horizontal position from the ground.

The adults have wings that nearly reach the end of the abdomen and some have wings that are

0.12 in (3 mm) longer than the abdomen. They have the ability of evasive flight. It is unknown if they have the capacity for dispersion or migration. At typical low densities, adults generally remain in the same area that they hatched. The obscure grasshopper is a phytophilous species, spending most of the day sitting vertically head up on the stems and leaves of grasses about 1 to 2 inches (2.5 to 5.1 cm) above ground. After sunrise and before sunset, both nymphs and adults bask by directly exposing a side or their back to the rays of the sun from a diagonal position on a blue grama plant, on a small mound of bare soil, or on bare ground. During the basking period, the ground temperatures range from 70° to 100° F (21° to 38° C) and air temperatures range from 64° to 83° F (18° to 28° C). Normal activities begin when the ground temperature is 85° F (29° C) or above and air temperature is around 70° F (21° C). During the afternoon when soil temperatures are from 110° to 130° F (43° to 54° C) and air temperatures are 90° F (32° C) or above, the grasshoppers avoid overheating by resting in the shade of canopy vegetation on blue grama above the ground, move to a diagonal position on blue grama facing the sun to expose less body surface, or climb a midgrass stem to a height of up to 4 in (10.2 cm) above the ground to reduce their body temperature through evaporative cooling by hyperventilation.

Population densities of the obscure grasshopper are usually low at around 0.1 to 2.2 adults/yard² (0.12 to 2.6/m²). The population densities generally grow gradually for a couple of years and then increase at 3 to 5 fold in 1 year. The multispecies assemblages that include obscure grasshopper as a subdominant or codominant increase to greater densities on the short grass prairie or on short grass areas on the mixed grass prairie.

This summary life history of the obscure grasshopper was based primarily from the work of Pfadt 1994 with additional information from Mulkern et al. 1969, Watts et al. 1989, Carruthers et al. 1992, and Onsager 2000.

Life History of the fourspotted grasshopper

Phlibostroma quadrimaculatum (Thomas) (Phl qua), the fourspotted grasshopper, is a serious codominant pest on rangelands, primarily in the mixed grass prairie and it can become a major economic pest on dry upland grassland areas that have a dominance of blue grama and other short grasses and mixed in mosaic patches with mid grasses in the short grass and mixed grass prairies. The fourspotted grasshopper has wide distribution in central North America and it inhabits the rangelands of the Northern Plains. It is a member of the Gomphocerinae subfamily of slantfaced grasshoppers. The adults are small sized grasshoppers. Live weight of the males average 110 mg and the females average 300 mg. Body length of the males is 0.57 to 0.59 in (14.5 to 15.0 mm) and the females is 0.73 to 0.85 in (18.5 to 21.5 mm).

The hatching period is with the intermediate group starting about early to mid June and lasting 2 to 3 weeks. The male nymphs usually develop through 4 instar stages, occasionally 5 instar stages. The female nymphs develop through 5 instar stages. Nymphal development lasts 33 to 55 days, with an average of 48 days. The fledgling adults require a period of about 2 weeks for growth and maturation after they appear. The females are nearly 3 times larger than the males. The males chase after moving females, if the female stops, she is courted with an intraspecific stridulation song. The females require a period for egg development after mating. Gravid females deposit 6 to 14 eggs per clutch in a tough pod that is 0.88 to 1.0 in (22.2 to 25.4 cm) long placed into bare ground, near buffalograss, blue grama, or other short grass, at about 1 inch (25 mm) in depth. The eggs begin embryonic growth in the summer of deposition and continue until they enter diapause; the following spring, the embryos complete development and emerge.

The fourspotted grasshopper is graminivorous and feeds almost exclusively on grasses. The preferred food plants are blue grama and buffalograss but will also feed on needle and thread, western wheatgrass, sand dropseed, sideoats

grama, and prairie sandreed. Rarely do they feed on upland sedges or forbs. The grasshopper climbs up a green leaf blade, turns around hanging onto adjacent leaves, and feeds on the entire width from about 1 inch (2.5 cm) below the tip toward the base. Sometimes the grasshopper sits horizontally within the grass crown and feeds on green leaves from near the tip to the base. The fourspotted grasshopper is a thrifty feeder and only small amounts of clipped leaf parts fall to the ground and become litter.

Typical low densities on rangeland are 0.2 to 1.5/yd² (0.24 to 1.8/m²). The adults have functional wings, however, most adults remain in the same area that they hatched. The fourspotted grasshopper is geophilous and spends most of the time on the ground. At night, both nymphs and adults rest on areas of bare ground or on litter near blue grama or other short grass. After sunrise and before sunset, they bask horizontally on the ground by exposing their side to the rays of the sun. During the day when the soil temperatures are 70° F (21° C) or greater, adults perform normal activities of mating, feeding, and pottering (walking around aimlessly). The percent time engaged in daily activities was 76.8% basking, 18.4% pottering, and 5.8% feeding. When soil temperatures rise to 100° F (38° C), individuals stilt by raising up on their legs and hold their bodies off the hot ground. When soil temperatures rise to 120° F (49° C), they move into blue grama plants and climb up 0.5 to 4.0 inches (1.3 to 10.2 cm) above the ground and face the sun. Grasshoppers can reduce their body temperature through evaporative cooling by hyperventilation.

Populations of fourspotted grasshoppers increase with other species of the outbreak assemblages. However, they are usually codominant or subdominant. No information is available on how rapidly or under what conditions populations increase to outbreak numbers.

This summary life history of the fourspotted grasshopper was based primarily from the work of Pfadt 1994 with additional information from Mulkern et al. 1969, Watts et al. 1989, Carruthers et al. 1992, Jech 1996, and Joern et al. 1996.

Life History of the largeheaded grasshopper

Phoetaliotes nebrascensis (Thomas) (Phoeb), the largeheaded grasshopper, is a common and often dominant pest on rangelands, primarily on tall lush grass areas in the tall grass and mixed grass prairies, it has been associated with a local outbreak in western North Dakota, it is a pest on crested wheatgrass pastures, and it is considered to be a major pest on winter wheat cropland. The largeheaded grasshopper has wide distribution in the central region of North America and it inhabits the rangelands of the Northern Plains. It is a member of the Melanoplinae subfamily of spurthroated grasshoppers. The adults are medium sized grasshoppers. Live weight of the males average 206 mg and the females average 419 mg. Body length of the males is 0.70 to 0.76 in (17.8 to 19.4 mm) and the females is 0.81 to 0.89 in (20.5 to 22.5 mm).

The hatching period is with the late group starting about mid to late June and lasting 4 or more weeks. The nymphs develop slowly through 5 instar stages in about 55 days. The adults appear between mid July and early August. The fledgling adults require a period of growth and maturation after they appear. Males and females form mating pairs. Because of the males much smaller size, the female's genitalia must curve up to meet the male's curving down. Females require a period for egg development after mating. Gravid females deposit 20 to 28 eggs per clutch in a curved pod that is 1.0 to 1.25 in (25.4 to 31.8 mm) long placed into bare ground at a depth of an inch (25 mm) or more. The eggs begin embryonic growth in the summer of deposition and continue until they enter diapause; the following spring, the embryos complete development and emerge.

The largeheaded grasshopper is graminivorous and feeds almost exclusively on

grasses. The main food plants are little bluestem, big bluestem, western wheatgrass, and kentucky bluegrass. The grasshopper feeds either head up or head down and eats the edge of the leaf, creating a long gouge along one side, and leaving a narrow edge of the leaf intact. This grasshopper does not eat litter on the ground.

Most adults have short wings and do not fly but can disperse from dry vegetation to green vegetation or to winter wheat cropland. A few adults have well developed long wings and are strong fliers. At typical low densities, most adults remain in the same area that they hatched. Long winged adults tend to disperse to new areas. The largeheaded grasshopper is phytophilous and spends most of the day on grass stems and leaves. During warm nights, the grasshoppers rest vertically head up on grass leaves at heights of 6 to 12 inches (15.2 to 30.5 cm). During cold nights, the grasshoppers rest close to the ground or under litter. After sunrise and before sunset, they bask by turning a side perpendicular to the rays of the sun while resting vertically head up on tall grasses. In habitats of short or mid grass or grazed tall grass, the grasshoppers bask by sitting horizontally on bare ground.

Population densities of largeheaded grasshoppers are usually 3 to 4 adults/yard² (3.6 to 4.8/m²) and increase to much higher densities during outbreaks. The highest densities are reached in habitats of lush tall grass in the tall grass and mixed grass prairies that provide an abundance of food.

This summary life history of the largeheaded grasshopper was based primarily from the work of Pfadt 1994 with additional information from Mulkern et al. 1969, Watts et al. 1989, and Onsager 2000.

Life History of the kiowa grasshopper

Trachyrhachys kiowa (Thomas) (Tra kio), the kiowa grasshopper, is a injurious codominant pest on rangelands, primarily on short grass areas dominated by blue grama in the mixed grass and tall grass prairies and it is a pest on crested wheatgrass pastures. The kiowa grasshopper has wide distribution across North America and it inhabits the rangelands of the Northern Plains. It is a member of the Oedipodinae subfamily of bandwinged grasshoppers. The adults are small sized grasshoppers. Live weight of the males average 148 mg and the females average 303 mg. Body length of the males is 0.59 to 0.71 in (15.0 to 18.0 mm) and the females is 0.67 to 0.94 in (17.0 to 24.0 mm).

The hatching period is with the intermediate group starting about early to mid June and lasting 2 to 4 weeks. The nymphs develop through 5 instar stages in 37 to 53 days. The fledgling adults require a period for growth and maturation after they appear. The males court the females on the ground with single stridulating strokes of both hind femurs. Females require a period for egg development after mating. Gravid females deposit 8 to 10 eggs per clutch in a fragile pod that is 1.13 to 1.25 inches (28.6 to 31.8 mm) long placed into bare ground near short grasses. The eggs begin embryonic growth in the summer of deposition and continue until they enter diapause; the following spring, the embryos complete development and emerge.

The kiowa grasshopper is graminivorous and feeds almost exclusively on grasses and sedges. The preferred food plant is blue grama but will also feed on western wheatgrass, needle and thread, threadleaf sedge, needleleaf sedge, sunsedge, and kentucky bluegrass. The grasshopper feeds on the green leaf blades from the tip to the base. Sometimes, they may climb into a grass crown and feed head down on leaf

blades. Preferentially, they remain on the ground, raise up on the hindlegs, hold a cut leaf blade with the front tarsi, and consume the leaf from tip to base. They do not eat litter from the ground.

Typical low densities on rangeland are 0.1 to 2.0/yd² (0.12 to 2.4/m²). The adults have very long wings and have moved as migratory swarms. However, the majority of adults remain in the same area that they hatched. The kiowa grasshopper is geophilous and spends most of the time on the ground. At night, both nymphs and adults rest on the ground in bare areas without a grass canopy overhead. After sunrise and before sunset, they bask on the ground by exposing their side or back to the rays of the sun. During the day when soil temperatures are less than 90° F (32° C) and air temperatures are less than 80° F (27° C), the grasshoppers spend most of the time on the ground. The percent time engaged in daily activities was 36.8% basking, 31.4% pottering, and 31.7% feeding. When soil temperatures rise to 130° F (54° C), individuals climb grasses and forbs to rest 0.5 to 1.0 inch (1.3 to 2.5 cm) above ground level, or they may remain on the ground but move to areas shaded by vegetation.

Populations of kiowa grasshopper may remain at low densities for 5 or more years. Under favorable conditions the population can increase 3 to 7 fold in 1 year. The increase to outbreak densities occurs in assemblages that include the bigheaded and the whitewiskered grasshoppers. The kiowa grasshopper usually remains a codominant in the outbreak assemblage.

This summary life history of the kiowa grasshopper was based primarily from the work of Pfadt 1994 with additional information from Mulkern et al. 1969, Watts et al. 1989, Belovsky et al. 1990, Jech 1996, and Onsager 2000.