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James D. Hansen
USDA-ARS, Crops Research Laboratory, Utah State University, Logan, Utah 84322

Robert S. Nowak
Department of Range, Wildlife & Forestry, University of Nevada- Reno, Reno, Nevada

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Feeding Damage by *Irbisia pacifica* (Hemiptera: Miridae): Effects of Feeding and Drought on Host Plant Growth[1]

JAMES D. HANSEN[2,3] AND ROBERT S. NOWAK[4]

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ABSTRACT The interaction of feeding by a grass bug, *Irbisia pacifica* (Uhler), and drought stress on growth of Great Basin wildrye, *Leymus cinereus* (Scrib. & Merr.) Löve, and intermediate wheatgrass, *Thinopyrum intermedium* (Host) Barkw. & D. R. Dewey, was studied in the greenhouse. At peak production, control plants of Great Basin wildrye had more than twice as much green leaf area per tiller than bug-infested ones, and intermediate wheatgrass controls had three times as much as the bug-infested plants. Total leaf area of control plants also exceeded that of bug-infested plants. Watered plants of both species recovered very little after bugs were removed. Drought conditions augmented the reduction in green leaf area on previously bug-infested plants of Great Basin wildrye but not on previously infested intermediate wheatgrass plants. Thus, when plants were well watered, bug feeding affected growth of intermediate wheatgrass more than growth of Great Basin wildrye. However, when plants were subjected to bug feeding and drought stress, the vigor of Great Basin wildrye was reduced more than that of intermediate wheatgrass. For both species, the potential forage for livestock consumption was lost because of direct damage by bug feeding as well as indirect effects on the acquisition or allocation of plant resources to growth.

KEY WORDS Insecta, grass bug, wheatgrass, wildrye

A GRASS BUG, *Irbisia pacifica* (Uhler), is widely distributed throughout the western United States and occupies most ecoregions (Schwartz 1984). This insect attacks many types of grasses (Schwartz 1984, Hansen 1986). In the Great Basin and Intermountain Region, it can be economically damaging to Great Basin wildrye, *Leymus cinereus* (Scrib. & Merr.) Löve (Knowlton 1951, Lauderdale & Knight 1982). The grass bug also attacks pastures of intermediate wheatgrass, *Thinopyrum intermedium* (Host) Barkw. & D. R. Dewey (Hansen 1988).

Previous studies on feeding behavior of *I. pacifica* evaluated the effects of feeding damage on chlorophyll concentration and specific leaf mass in crested wheatgrass, *Agropyrum desertorum* (Fisch. ex Link) Schultes (Hansen & Nowak 1985) and feeding site selection among and within leaves (Hansen 1987). Field observations concerning the relationship between feeding and growth in intermediate wheatgrass were reported by Hansen (1988). Nevertheless, the degree of growth reduction caused by *I. pacifica* feeding had not been determined. Also unknown is how *I. pacifica* feeding interacts with other stresses, particularly drought, on host plant growth. Summer drought commonly follows spring feeding by grass bugs.

Our objectives in this study were to measure the reduction in growth of two common host plants caused by moderately high feeding levels of *I. pacifica*, and to examine postfeeding recovery in plants under drought and watered conditions.

Materials and Methods

The research was conducted in the greenhouse from May to July 1985, at the USDA–ARS Crops Research Laboratory, Logan, Utah. The host plants were Great Basin wildrye and intermediate wheatgrass. All plants were grown in the greenhouse and initially had more than one tiller. A single tiller with at least three leaves was selected as representative of each plant, and the remaining tillers were removed. Plants of the same species were arranged in two rows of four plants each within a cage with Plexiglas sides (25 by 28 by 47 cm) and a plastic screen top. For each grass species, three cages were used as controls and three other cages were stocked with adults of *I. pacifica* (100 bugs per cage). The bugs were collected from a field of intermediate wheatgrass about 3 km NE of North Logan, Utah. All bugs were replaced each week at the same initial stocking rate during the feeding phase of the study.

The drought-stress phase began after the field population of *I. pacifica* declined (week 5, mid-June). All bugs were removed from cages to prevent further feeding damage, then half the plants of each treatment for each species were separated and not watered to promote drought stress. The others were watered as usual. This phase ended when the drought-stressed plants approached senescence. Although no attempt was made to simulate exactly the development of water stress under

[1] Mention of a commercial or proprietary product does not constitute endorsement by the USDA.

[2] USDA–ARS, Crops Research Laboratory, Utah State University, Logan, Utah 84322.

[3] Current address: USDA–ARS, Tropical Fruit & Vegetable Research Laboratory, P.O. Box 4459, Hilo, Hawaii 96720.

[4] Department of Range, Wildlife & Forestry, University of Nevada-Reno, Reno, Nev. 89512.

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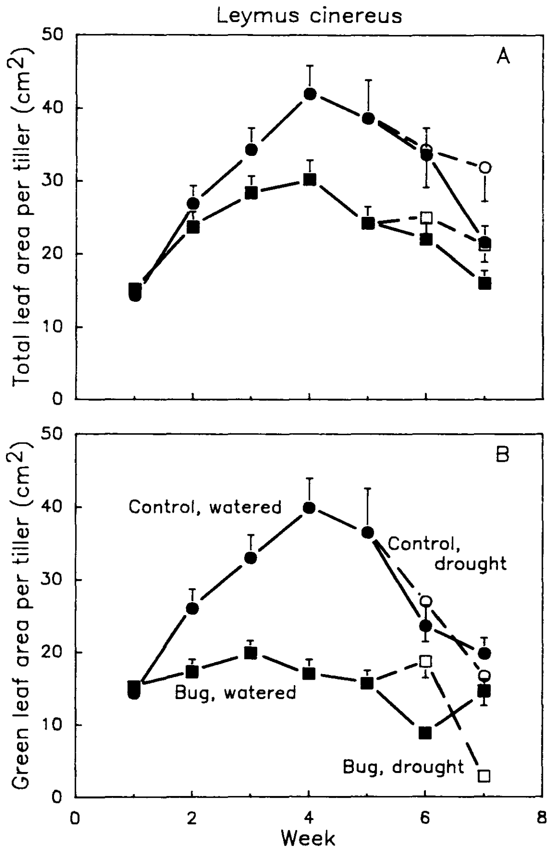

Fig. 1. Effects of feeding by *I. pacifica* on leaf production in Great Basin wildrye under watered and drought conditions. Circles, controls; squares, bug-infested treatments; closed symbols and solid lines, water treatment; open symbols and dashed lines, drought treatment. (A) $\bar{x} \pm$ SE for total leaf area (cm^2) per tiller; (B) $\bar{x} \pm$ SE for green leaf area (cm^2) per tiller.

field conditions, the drought-stress treatment in the greenhouse paralleled that to be expected under natural conditions.

All leaves were measured weekly for length, width, condition, and location on each tiller (or plant). Bug feeding, expressed as "% damage," was visually evaluated for all leaves, a procedure routinely used to estimate damage caused by grass feeding mirids (Hansen et al. 1985a,b). Total leaf area (TLA) was estimated by multiplying length by width, then the undamaged green leaf area (GLA) was calculated by subtracting the amount of leaf area damaged by feeding from total leaf area.

Data were analyzed at the USDA Washington Computer Center using the Statistical Analysis System with the MEANS procedure (SAS Institute 1982). Student's t tests were done with a Hewlett-Packard HP-11C calculator.

Voucher specimens have been placed in the Rangeland Insect Collection, USDA-ARS Crops Research Laboratory, Logan, Utah.

Results

Initially, average TLA per tiller was similar between control and bug-infested plants within both species (Fig. 1A and 2A). However, by the fourth week, average TLA per tiller of controls was about 40–50% more than that of bug-infested plants. After the fourth week, average TLA per tiller of all plants declined. At the end of the study, average TLA per tiller in drought-stressed plants of intermediate wheatgrass was lower than that of watered plants (Fig. 2A), whereas in Great Basin wildrye, average TLA per tiller of drought-stressed plants tended to exceed that of watered plants (Fig. 1A).

A second indicator of plant growth, average green leaf area (GLA) per tiller, represented the available photosynthetic leaf tissue. Controls of both plant species grew well during the first month of the study (Fig. 1B and 2B). Peak growth (maximal GLA) for controls of Great Basin wildrye ($\bar{x} \pm SE = 39.9 \pm 4.0\ cm^2$) and intermediate wheatgrass ($\bar{x} \pm SE = 37.3 \pm 3.1\ cm^2$) occurred during the fourth week. Bug-infested Great Basin wildrye showed some growth (Fig. 1B), whereas average GLA per tiller of bug-infested intermediate wheatgrass remained about the same (Fig. 2B). Average GLA per tiller from control plants was significantly greater than that from bug-infested plants at the second week for both Great Basin wildrye ($t = 2.74$; df = 46; $P < 0.01$) and intermediate wheatgrass ($t = 7.83$; df = 46; $P < 0.01$). This significant difference persisted at least as long as bugs were on the plants. By the fourth week, average GLA per tiller of bug-infested Great Basin wildrye ($\bar{x} \pm SE = 17.0 \pm 2.0\ cm^2$) was 57% less than peak GLA of the control, and average GLA per tiller of bug-infested intermediate wheatgrass ($\bar{x} \pm SE = 12.2 \pm 1.3\ cm^2$) was 67% less than maximal GLA of the control.

In the drought phase of the study, which began after the bugs were removed, Great Basin wildrye was more severely affected than intermediate wheatgrass. The Great Basin wildrye plants were without water for 2 wk before the study was terminated because of imminent mortality. The drought-stressed intermediate wheatgrass plants persisted for 5 wk. Average GLA per tiller in Great Basin wildrye dropped dramatically in the drought-stressed plants; the greatest decline occurred in previously bug-infested plants (Fig. 1B). Average GLA per tiller in intermediate wheatgrass also declined for drought-stressed plants. To assess the interaction between aridity and preceding insect feeding, ratios of the average GLA of drought-stressed plants to watered plants were compared between control and bug-infested treatments. On the last week of the experiments, these values were 0.40 and 0.36 for control and bug-infested intermediate wheatgrass, respectively, and 0.84 and 0.19 for the same respective treatments of Great Basin wildrye. No recovery after bug removal was ap-

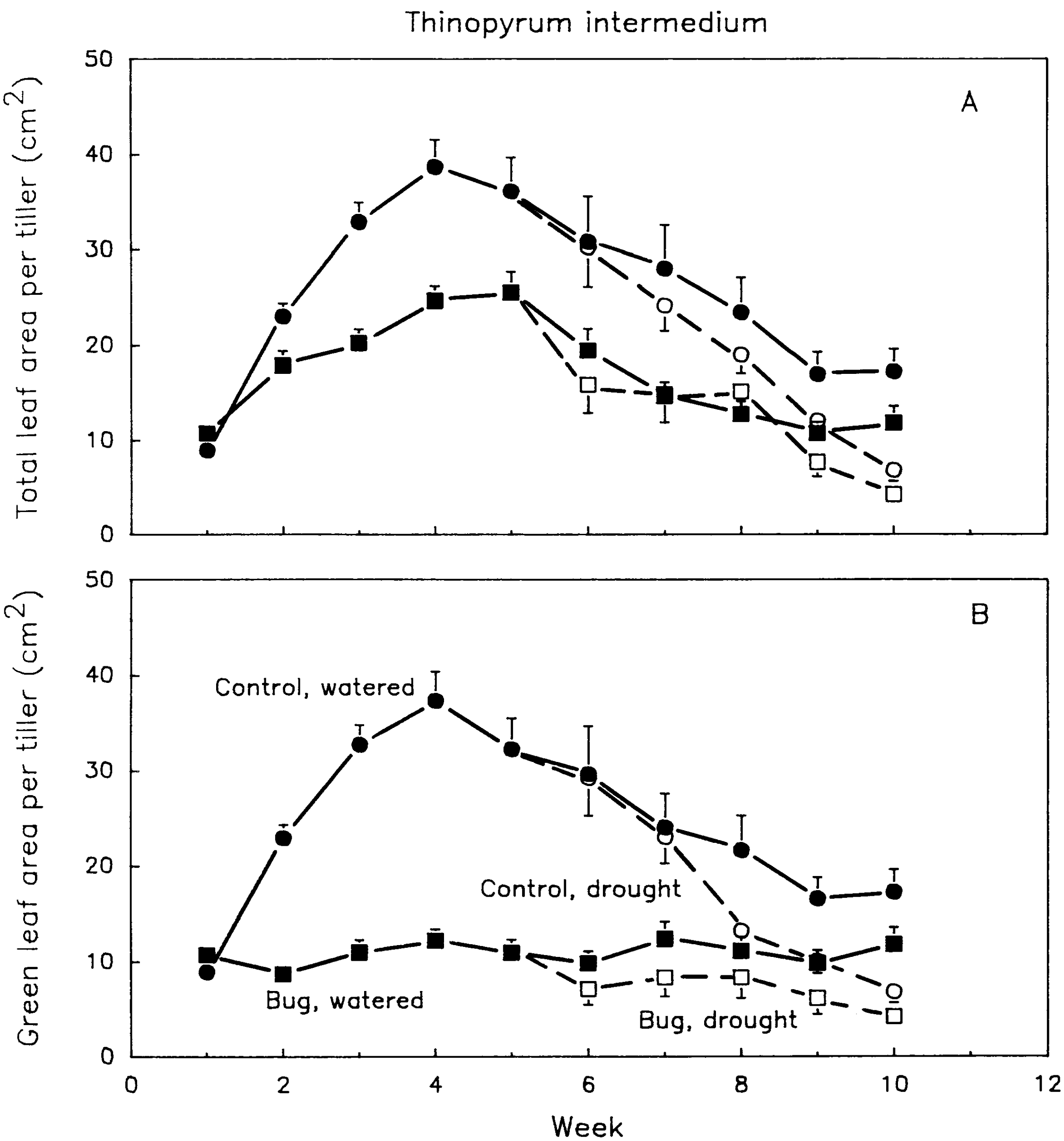

Fig. 2. Effects of feeding by *I. pacifica* on leaf production in intermediate wheatgrass under watered and drought conditions. Circles, controls; squares, bug-infested treatments; closed symbols and solid lines, watered treatment; open symbols and dashed lines, drought treatment. (A) $\bar{x} \pm$ SE for total leaf area (cm^2) per tiller; (B) $\bar{x} \pm$ SE for green leaf area (cm^2) per tiller.

parent in watered, bug-infested plants of either grass species.

A third possible method to express plant growth was by the number of green leaves per tiller in a treatment. Initially, bug-infested plants of Great Basin wildrye averaged more green leaves per tiller than control plants (Fig. 3). However, after the third week, control plants consistently had more green leaves per tiller than bug-infested plants. The number of green leaves per tiller was very similar between control and bug-infested intermediate wheatgrass plants throughout the study. Student's *t* tests at the fifth week, when bugs were removed, showed significant differences in the number of green leaves per tiller between control and bug-infested treatments for Great Basin wildrye (t = 3.30; df = 45; $P < 0.01$) but not for intermediate wheatgrass. By the end of the study, watered Great Basin wildrye plants of both treatments lost leaves (Fig. 3), whereas the number of green leaves per tiller of intermediate wheatgrass increased slightly (Fig. 4).

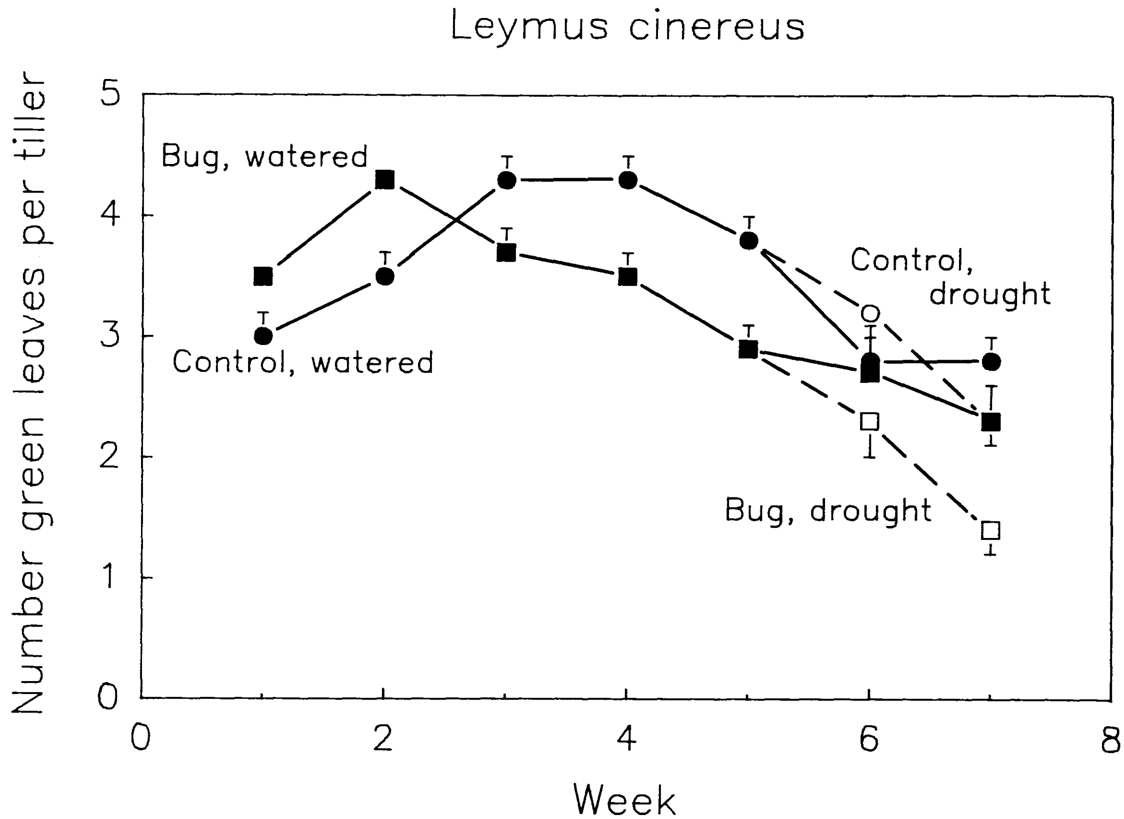

Fig. 3. Number ($\bar{x} \pm$ SE) of green leaves per tiller in Great Basin wildrye control plants and plants infested with *I. pacifica* under watered and drought conditions. Circles, controls; squares, bug-infested treatments; closed symbols and solid lines, watered treatment; open symbols and dashed lines, drought treatment.

Drought stress reduced the number of green leaves per tiller in control and bug-infested plants of both species. There were significant differences in the number of green leaves between drought-stressed and watered plants, in the control treatment ($t = 5.07$; df = 19; $P < 0.01$) and bug-infested treatment ($t = 7.18$; df = 16; $P < 0.01$) of intermediate wheatgrass as well as the bug-infested treatment ($t = 2.34$; df = 18; $P < 0.01$) of Great Basin wildrye, but not its control treatment.

Discussion

Direct effects of feeding damage on leaf tissue and indirect effects on leaf growth potential were observed for both species in this study. Although TLA per tiller (Fig. 1A and 2A) and the number of leaves per tiller (Fig. 3 and 4) for both grass species increased while being attacked by *I. pacifica*, the average GLA per tiller of bug-infested plants remained relatively constant (Fig. 1B and 2B). Thus, these bugs damaged the green leaf tissue as rapidly as the plants formed new leaf tissue. Differences in TLA per tiller between control and infested plants in the fourth week clearly demonstrate the reduction in growth potential by bug feeding over and above that caused by direct feeding damage (Fig. 1A and 2A). This suggests that feeding reduces plant resources that are available or allocated to growth. Therefore, bugs affect GLA and potential growth, directly by consuming leaf tissue and indirectly by disrupting the acquisition or allocation of plant resources to growth.

Great Basin wildrye seems particularly susceptible to drought after bug feeding. Prior bug feeding on Great Basin wildrye increased reductions of GLA per tiller (Fig. 1B) and the number of green leaves per tiller (Fig. 3) during drought stress. The ratio of GLA of drought-stressed control plants to that of watered control plants (0.84) was more than four times greater than the ratio for bug-infested plants (0.19). The reduction in green leaves per tiller during drought stress was 42% for bug-infested plants, which was three times greater than that for control plants (14%).

In contrast, drought had no significant additive effects on intermediate wheatgrass. The GLA ratios of drought-stressed plants to watered plants were slightly greater for control plants (0.40) than for previously bug-infested plants (0.36). Drought stress caused a 55% reduction in the number of leaves per tiller in bug-infested plants, but this was not much greater than the 42% reduction in control plants.

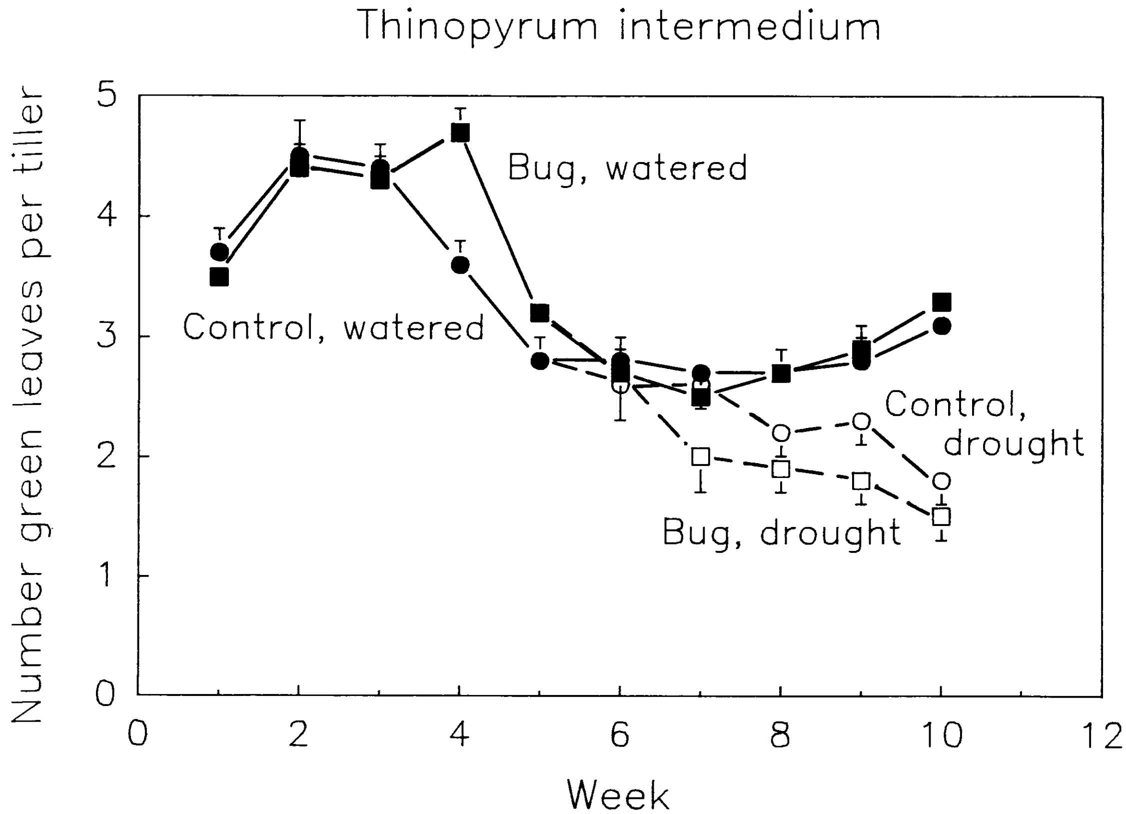

Fig. 4. Number ($\bar{x}$ ± SE) of green leaves per tiller in intermediate wheatgrass control plants and plants infested with *I. pacifica* under watered and drought conditions. Circles, controls; squares, bug-infested treatments; closed symbols and solid lines, watered treatment; open symbols and dashed lines, drought treatment.

The effects of feeding and of postfeeding drought stress differed between the two species. Intermediate wheatgrass, which had a greater difference in GLA per tiller between control and bug-infested plants, was more susceptible to *I. pacifica* feeding under well watered conditions than Great Basin wildrye. However, the interaction of prior bug feeding and drought resulted in a much larger reduction of GLA in Great Basin wildrye, even though this plant is the primary host of *I. pacifica*. This difference has interesting evolutionary implications, because both Great Basin wildrye and *I. pacifica* are native components of semiarid grasslands in the western United States where summer droughts commonly follow spring bug feeding.

Although the GLA in watered control plants of both species eventually declined due to natural aging, well watered, undamaged plants in a field situation would still produce more green forage available for grazing than bug-infested plants. Earlier, we (Hansen & Nowak 1985) determined that *I. pacifica* did not significantly reduce the specific leaf mass (ratio of leaf mass to leaf area) of crested wheatgrass leaves and noted that bug-infested plants could still provide the same amount of livestock forage per unit leaf area. Our current study showed a large reduction of both green and total leaf area caused by feeding by *I. pacifica* on Great Basin wildrye and intermediate wheatgrass, which would result in a net loss of potential biomass for livestock forage. Our data also indicated little recovery in plant growth, exhibited as increased GLA, after the cessation of bug feeding. Finally, a summer drought would reduce forage production in both species, but the relative reduction in areas that earlier had large populations of *I. pacifica* would not be as great for intermediate wheatgrass as for Great Basin wildrye.

The duration of adult feeding (4 wk) and postfeeding drought stress well represented what occurred in the field. Hansen (1988) found that adults of *I. pacifica* were present for about a month in a pasture of intermediate wheatgrass. The timing of attack was important because it allowed the plants to adjust to feeding stress. The initiation of drought stress in mid-June was similar to that of other grass species (Nowak & Caldwell 1984).

The infestation rate used in our study (12.5 bugs per plant) may be too high. Lauderdale & Knight (1982) conducted greenhouse studies with *I. pacifica* at a rate of 5–10 bugs per plant and concluded that this was higher than levels they found in infested rangelands; they felt that three bugs per plant was more realistic. Obviously, plant size was important for determining the number of bugs per plant, but Lauderdale & Knight did not report plant size. Nevertheless, our data show that severe feeding does cause serious damage to the plants.

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