and only development of appropriate local technology can solve the problems.

Because of setbacks which range management has received in pastoral situations, many donor agencies are now reluctant to invest in range management projects in developing countries. Grazing lands are there, and animals have grazed on these lands and would continue to do so whether range management programs succeed or fail. There is a need to develop a rangeland anthropology and sociology course in the range schools for those interested in international work and for the international students. Programs fail simply because prescriptions are made without a proper diagnostic analysis of the problem.

Most people think of range management the way they read about it in text books or have seen it in the developed countries. Therefore, there appears to be a need for an appropriate term which portrays the grazing situations in developing countries. This will lay a foundation for research and development in a new direction: pastoralism, nomadism, transhumance, or mixed farming systems. It is suggested that development and management of rangelands in developing countries be called Pastoral Systems Management.

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Viewpoint: Comments on the Proposed Use of Native Insects for Biological Control of Snakeweeds

J.P. Cuda

As a scientist currently involved in research on the biological control of weeds on rangelands. I would like to comment on the conclusions and recommendations of an article published in the April 1987 issue of *Rangelands* entitled "The Potential of Two Insects for Controlling Broom Snakeweed" (Gonzales 1987). Although I agree with the author that biological control would be an appropriate method for controlling broom snakeweed, *Gutierrezia sarothrae* (Pursh) Britt. & Rusby, I question the feasibility of the augmentation approach recommended by the author and also his assessment of one of the insects purported to be an important natural enemy of broom snakeweed.

I would also like to point out that a project on the biological control of snakeweed is already in progress at Temple, Texas. The program was developed in 1975 by Dr. C. Jack DeLoach, who is affiliated with the USDA, Agricultural Research Service (ARS). Dr. DeLoach is one of a small group of federal and university scientists working full- or part-time on biological control of weeds at several locations across the United States.

For the purpose of this discussion, biological control of weeds is defined as the use of insects, plant pathogens, or other organisms to control weeds (Huffaker 1959). It must be emphasized that "control" is not synonymous with "eradication"; the weed species controlled biologically is simply reduced to a level such that it is no longer considered economically important. Also, because this method of control is species specific, its effects are not detrimental to non-target species or to the environment.

The use of biological control on rangelands has been examined in detail by DeLoach (1978, 1981) and DeLoach et al. (1986). The two approaches of biological control that are currently available are (A) introduction of foreign organisms not already present (classical biological control), and (B) augmentation of the effectiveness of organisms already present in an area. The key issue here concerns the selection of the biological control method that is *appropriate* for use in a low-value per acre agricultural system such as rangelands where snakeweeds (perennials) and broomweeds (annuals) are important weeds. DeLoach (1981) states that "biological control is ideally suited to control rangeland weeds and brush of which the major pests are perennials growing in a relatively undisturbed habitat and in areas where the low economic return per unit area makes chemical and mechanical controls relatively expensive." He further states that the introduction of foreign control agents is more suitable than augmentation for use on rangelands because of its lower cost. DeLoach et al. (1986) recently compared the relative cost of biological control by augmentation and introduction. They clearly showed that the augmentation approach would be too expensive in a rangeland system because the cost for an augmentation program is proportional to the area treated. In this regard, the total cost and cost per acre is basically similar to control with herbicides. In contrast, the total cost of biological control by the introduction method is independent of the area treated and the cost per acre actually decreases over time as the introduced agents reproduce and

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actively seek out the weed.

DeLoach et al. (1986) identified several important weeds of rangelands of the southwestern U.S. and northern Mexico that are possible candidates for classical biological control. Snakeweeds and broomweeds headed the list of priority weeds because conflicts of interest would be minimal in both countries. DeLoach (1981) and DeLoach et al. (1986) considered broom snakeweed and threadleaf snakeweed, *G. microcephala* (DC.) Gray, to be the best candidates for classical biological control because the amount of damage caused by these snakeweeds exceeds any beneficial value these plants may have in the rangeland ecosystem. Also, the success potential of introduced biological control agents is favorable for snakeweeds. Several root-boring insects have been found in Argentina that have good control potential because they severely damage the taproots of four species of *Gutierrezia* that are similar ecologically to our North American snakeweeds (Cordo 1985, Cordo and DeLoach, in press). Host range testing of two of the more promising insects is in progress under quarantine conditions at the Temple laboratory.

From the previous discussion it can be argued that the augmentation approach as proposed by Gonzales (1987) would probably not be economical to the rancher. Increasing the effectiveness of the native phytophagous insects already attacking snakeweed by mass rearing and then releasing them would not be competitive with commercially available herbicides and, in all likelihood, would be prohibitive in the rangeland system where the production per unit area is very low. Although there are numerous examples of native insects occasionally controlling weeds (Ueckert 1973), to date only one augmentation program utilizing existing weed feeding insects has been attempted. Frick and Chandler (1978) mass reared and released the moth *Bactra verutana* Zeller to control purple nutsedge, *Cyperus rotundus* L., in cotton fields in Mississippi. The results of this pilot study showed that even though augmentation was technically feasible, a large scale augmentation program would not be cost effective in the current cotton production system and consequently was not implemented.

The rationale for augmenting an indigenous population is that the population to be augmented has a characteristic abundance that is maintained by some density dependent natural control factor(s) (e.g., predators, parasitoids, or pathogens), and when augmentation ceases, that population will revert to its former level (Huffaker et al. 1971). The insect fauna associated with snakeweeds clearly illustrates this principle of natural control.

Snakeweeds are attacked by a variety of insects (Falkenhagen 1978, Foster et al. 1981, Richman and Huddleston 1981, Wangberg 1982). The inability of the native insects to effectively control snakeweeds over large areas without augmentation suggests that parasitoids and predators are operating in a density-dependent fashion to keep these natural enemies of snakeweeds in check. This is an important point because Gonzales (1987) identified the checkered beetle *Enoclerus coccineus* (Schenk.) (Cleridae) as a potential biological control agent of broom snakeweed in New Mexico based on the presence of larvae found in the roots of a high percentage of dead or dying plants. This observation is surprising because the clerids rarely consume plant material and as a group are considered to be predaceous in both the larval and adult stages (Balduf 1935). Current specialists in clerid taxonomy still support the predatory behavior of the larval stage and suggest the larvae of *E. coccineus* are probably feeding on the immature stages of other beetles (W.F. Barr, D.E. Foster, pers. comm.). It is also noteworthy that the report of Dr. Gonzales does not exclude the possibility that the snakeweed plants examined were previously infested with other root-feeding insects.

I suggest that the larvae of *E. coccineus* were probably feeding on the root-boring larvae of *Crossidius pulchellus* LeConte (Cerambycidae) or possibly other insects. Richman and Huddleston (1981) reported that larvae of *C. pulchellus* were often sufficiently abundant in eastern and central New Mexico to kill snakeweed plants over 15 cm in height. They also found *Enoclerus* larvae associated with root tunnels constructed by *Crossidius* larvae. Furthermore, Falkenhagen (1978) observed larvae of *E. laetus nexus* Barr inside borer tunnels in the roots of broom snakeweed in Arizona; 88 percent of these larvae were associated with larvae of the root-boring weevil *Myrmex lineolata* (Pascoe)(Curculionidae). Falkenhagen (1978) also suggested the larvae of *E.l. nexus* were predaceous on the larvae of *M. lineolata.*

A discovery that *E. coccineus* is in fact feeding on the roots of snakeweed would represent an important exception to our present knowledge of the Cleridae and in particular the genus *Enoclerus*. Further documentation of such a phenomenon, under controlled conditions where the opportunity of prior infestation by other root-feeding insects were eliminated, would be of great interest to researchers studying clerid and snakeweed ecology and to those interested in biological control of snakeweeds.

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Rebuttal: Running the Gauntlet of Scepticism and Resistance in Scientific Research

G.J. Gonzales

Editor's Note: Readers may wish to refer to the paper "The Potential of two insects for controlling broom snakeweed," by G.J. Gonzles, *Rangelands* 9(2):59-61.

The comments concerning scientific research are the individual opinions of the authors and do not represent the official positions of the Society for Range Management or its representatives.

It is seldom possible to design an experiment that answers all research questions nor is it realistic to ignore potentially important oddities that may be observed in the course of scientific research. In a commentary on "The potential of two insects for controlling broom snakeweed", research which had been proposed on the biological control of broom snakeweed was questioned for various reasons.

The majority of concern in using the checkered beetle *E. coccineus* as a biological control agent is based on the premise that the augmentation method would be used. Although *E. coccineus* is native to the southwest, an extensive survey of insects associated with snakeweed in eastern New Mexico and western Texas revealed *E. coccineus* to be present in only 3 of 47 (6%) of the surveyed sites (Foster et al. 1981). This may indicate that *E. coccineus* is relatively "foreign" to snakeweed populations and, therefore, possibly should be researched as a classical biological control agent for the snakeweeds. In addition, in those sites in which *E. coccineus* was present its abundance was common. This may indicate that once invasion into snakeweed communites had occurred *E. coccineus* prospered. This warrants further consideration.

Assuming that *E. coccineus* would be used in an augmentation approach, Cuda (1988) concluded that the financial cost would be prohibitive compared to traditional herbicide control. Regardless of the approach of any pest control method, "cost" can no longer include only monetary values but must now consider environmental and health costs. Even rapidly biodegradable herbicides that have been used in very large volumes worldwide without causing health problems (Guthrie and Perry 1980, Ware 1978), are now suspect of causing health problems. For example, the National Cancer Institute indicates that farmers and workers exposed to herbicides face a much higher risk of lympathic cancer than others (NM Occupa, Health and Safety Bureau 1986). Farmers exposed to herbicides 20 or more days a year were 600% more likely to contract lympathic cancer. The highest cancer risk was associated with 2,4-D. Other carcinogens including cigarette smoke, radiation, and heredity were ruled out. Thus, even where the "total [financial] cost [of a biological control method] is similar to control with herbicides," biological control warrants further consideration.

The high correlation between dead or dying snakeweed plants and evidence of *E. coccineus* in snakeweed roots (Gonzales 1987) must be put into perspective. While the likelihood of this insect being herbivorous or omnivorous is minimal as discussed by Cuda (1988), the oddity of the correlation should not be ignored for reason of not being in accord with current beliefs. Furthermore, while not assuming that because the two factors were correlated the relationship was necessarily one of cause and effect, I could not rule out that possibility on the basis of instinctive mental resistance to new ideas.

In deciding whether a line of research should be followed, one should not be put off it merely because the idea has already been thought of or tried without leading to expected results (Beveridge 1957). If, for example, native snakeweed-destroying insects are being regulated by density-dependent natural control factor(s), it may be that their populations could be regulated using pheromone "confusion". Finally, while not encouraging abandonment of the critical attitude or hasty acceptance of ideas until they have been well proved and tried, successful research may include conventional and/or novel approaches (Beveridge 1957).

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