Invasion of *Imperata cylindrica* (L.) Beauv. by *Eupatorium* Species in Northern Thailand

J. LINDSAY FALVEY AND PRAKOB HENGMICHAJ

Abstract

The pattern of invasion of native *Imperata cylindrica* swards by *Eupatorium* in the highlands of northern Thailand was studied by the technique of comparing invasion at different sites of known history. *Eupatorium* ground cover decreased with increasing distance from the night camp of cattle. Variations in the curves between different villages was attributed to the number of years of sustained grazing each site had undergone. A more detailed study of one area showed a high correlation ($r=0.887$) between mean percent *Eupatorium* and the number of years of grazing, but not for estimated average stocking rate at each site. The correlation coefficient between percent *Eupatorium* and the product of the number of years grazing and estimated average stocking rate at each site was also high ($r=0.894$). Some agronomic data for *E. adenophorum* in one area are also presented.

The highlands of north Thailand are populated by seven main ethnic groups who practice shifting cultivation on the steep slopes. While their prime agricultural interest is in subsistence crops or cash crops, primarily opium, ruminant livestock in the form of cattle, buffalo, and goats are also raised. Of these, cattle are present in the greatest numbers by far, and represent a relatively high income-producing potential (Falvey 1977).

Imperata cylindrica (L.) Beauv. is distributed throughout most of the tropical world, where it is usually considered to be a weed and has therefore mainly been studied in terms of control (Iven 1975). In the highlands of northern Thailand, however, it forms the basis of the present grazing industries. *Imperata* often populates the abandoned swiddens of shifting cultivators and persists through its fire-evading characteristics. Fires escape from the annual preparation of new swiddens and burn large proportions of the highlands each year.

It is envisaged the *Imperata* pastures will remain important in the highland situation because, although productivity of cattle grazing these native pastures is low (Falvey et al. 1978), increases in productivity can be obtained through simple supplementation (Mikled 1976). Animal production figures from more tropical countries where *Imperata* is the main pasture are considerably higher (Magadan et al. 1976), a factor that is probably related to the relative vigor of the swards due to differences in soil fertility and other environmental conditions. A compounding problem of the lower vigor of *Imperata* swards in the highlands of north Thailand is the invasion by unpalatable broadleaved species of the *Eupatorium* genus under grazing.

Eupatorium odoratum (L.) (also known as *Chromolaena odorata* (L.) R.M. King and H. Robinson) is widely distributed in the tropics although it is believed to be a native of the West Indies and Central America. It is a perennial, diffuse, scamb-

ling plant with a deep taproot (Holm et al. 1977). It can grow up to heights of 3 meters under favourable environmental conditions and its invading ability is enhanced by prolific annual seed production and a profuse branching habit (Holm et al. 1977). An allelopathic effect of *Eupatorium* species has also been suggested (C. Parker, pers. comm.). The species cannot usually persist in a closed canopy forest situation as the plants have light requirements (Ivens 1975), although *E. adenophorum* may be more tolerant to shading than *E. odoratum*, at least in the seedling stage (Auld and Martin 1975). Both species prefer well-drained soils (Holm et al. 1977). In the highlands of north Thailand (latitude 17° – 24° N), Gibson (1976) has noted that *E. adenophorum* is usually encountered at altitudes greater than 1,100 metres while *E. odoratum* occurs at the lower altitudes although there are exceptions to the trend.

The mechanism of invasion by *Eupatorium* into grazed swards of *Imperata* has not been defined. Casual observations indicate that invasion by *Eupatorium* increases with the length of time an area of *Imperata* has been grazed. The shifting cultivation pattern of the highland dwellers and the associated removal of villages at intervals of 10–15 years have meant that the effects of high levels of weed invasion have been avoided. Increased population in the area and decreased land available for cultivation due to government activities such as reforestation, have significantly reduced the scope of village removal and have therefore highlighted the problem of *Eupatorium* invasion of *Imperata* pastures and, to a certain extent in cropping areas.

This paper attempts to describe some of the dynamics of *Eupatorium* invasion, some characteristics of the species in the environment of the highlights of north Thailand, and the probable role of the species in vegetational change.

Methods

This work was conducted during 1976–77 at various sites in the highlands of northern Thailand at altitudes ranging from 700–1,400 metres. The proportion of *Eupatorium* species at approximately 60 random sites at varying distances around the night camp of cattle was estimated by visual estimation of the percentage ground cover at six villages. For the purposes of this study no distinction was made between the different *Eupatorium* species. The villages chosen for this study had all raised cattle at numbers greater than 20 head for varying numbers of years. The number of years the villages had been located at that site, or alternatively, the number of years for which cattle had been raised were also recorded.

At Pa Kia, the research site of the Thai-Australian Highland Agricultural Project, a similar though more detailed study was conducted. Information concerning the stocking pressure a given area may have received in a particular year was available as were accurate

Authors are livestock specialists, Thai-Australian Highland Agricultural Project, Faculty of Agriculture, Chiang Mai University, Chiang Mai, Thailand.
Manuscript received June 25, 1978.

Fig. 1. Mean percent *Eupatorium* invasion into native *Imperata* pastures in terms of ground cover at varying distances from six villages.

total stock numbers per year. The parameters used and their derivation are presented in Table 1.

Agronomic data for *E. adenophorum* in the form of flowering time, seeding time, height, depth of roots, density in pure swards, and dry matter per plant were recorded at Pa Kia. Nutrient content of *Eupatorium* was also recorded. These data were collected from a stand of *E. adenophorum* at Pa Kia, an area of granite-derived soils where cattle have been raised for more than 5 years.

Results

Figure 1 describes the relationship between the percentage of *Eupatorium* at varying distances from six villages. The curves

described are, in each case, convex to the origin, although there is some variability within curves. The degree of invasion at a particular distance from the village varies with the village concerned.

In Figure 2 the average ground cover of *Imperata* at varying distances from the same six villages as those used in Figure 1 are presented. The general shape of these curves shows an exponential tendency at lower values on the distance scale although the overall tendency may be a straight line. The *Imperata* ground cover at a particular distance from the village varied with the village concerned.

Fig. 2. Mean percent *Imperata* ground cover at varying distances from six villages.

Table 1. Parameters used in the analysis of *Eupatorium* invasion data at Pa Kia.

Term	Explanation
Distance from the camp.	The estimated straight-line distance from the night camp of cattle.
Potential average stock numbers per year.	The average number of stock present in 1 year that could have grazed on the area in question under the free range conditions.
Maximum number of stock per year.	The maximum number of stock present during 1 year that could have grazed on the area in question.
Number of years grazing	The number of years that cattle had been allowed access to that area.
Estimated average stock numbers per year	The average number of stock that were present in 1 year adjusted by the proportion of their grazing time estimated to be spent in that area.

The degree of correlation of *Eupatorium* ground cover in the vicinity of Pa Kia to various parameters is presented in Table 2. Correlation coefficients between the percentage *Eupatorium* ground cover and the parameters "distance from the camp" and the "maximum number of stock" that grazed each area in 1 year were reasonably high, while the value for the correlation to the number of years grazing was the highest. Correlation coefficients between *Eupatorium* percentage ground cover and the products of some other parameters were high, in particular the product of "number of years grazing" and "estimated average stock numbers per year."

Figure 3 presents the data for the mean percentage of *Eupatorium* over various years of grazing at Pa Kia. The straight line relationship calculated from this data was $Y = -4.4 + 19.6X$ and is also included in the graph. The data for the relationship between the percentage *Eupatorium* ground cover and the product of the terms "number of years grazed" and "estimated average stocking rate" are presented as Figure 4. The straight

Table 2. Correlation coefficients between various parameters and *Eupatorium* ground cover at Pa Kia.

Parameter	r
(A) Distance from camp	0.489
(B) Potential average stock numbers per year	0.083
(C) Maximum number of stock per year	0.591
(D) Number of years of grazing	0.887
(E) Estimated average stock numbers per year	0.293
(A) × (B)	0.384
(A) × (C)	0.346
(A) × (D)	0.000
(A) × (E)	0.173
(D) × (E)	0.894
(D) × (B)	0.781
(D) × (C)	0.761

line relationship calculated from the data was $Y = -1.6 + 3.2X$.

Figure 5 presents the degree of *Eupatorium* invasion within an area of radius 1 km (excluding areas of difficult access) around seven villages, by the number of years the villages have been established or raised cattle in numbers greater than 20 head. The curve shows a general upward trend and a relationship of the form $Y = 43.96 + 2.71X$ was calculated.

Agronomic data about *E. adenophorum* in the vicinity of Pa Kia are presented in Table 3. Flowering appeared to be uniform

Table 3. Some agronomic details of *Eupatorium adenophorum* at Pa Kia.

Characteristic	Value
Month of flowering	February
Month of first seed set	Mid-March
Average height at maturity (cm)(March)	135
Maximum height at maturity (cm)(March)	243
Density in pure sward (plants per m ²)	5.1
Mean root depth(cm)	56.5
Maximum root depth(cm)	78.0
Mean dry matter per mature plant(g)	
Leaves and flowers(March)	17.9
Woody stem	112.8

Fig. 3. Mean percent *Eupatorium* ground cover at various sites grazed for varying periods at Pa Kia.

Fig. 4. Mean percent Eupatorium ground cover versus the product of number of years—estimated average stocking rates.

regardless of site, but seed maturity seemed to be related to site exposure or moisture stress. Analysis of oven-dry *E. adenophorum* on 8/10/77 showed nitrogen and phosphorus contents of 2.13% and 0.25% respectively.

Discussion

Invasion of *Eupatorium* species into *Imperata cylindrica* pastures is most probably related to grazing pressure, which would be expected to decrease with increasing distance from a village where cattle usually return of an evening. The curves in

Figure 1 indicate similar trends, and the difference in curves can probably be related to the duration of the grazing pressure, as indicated by Figure 5. That this relationship is linear rather than exponential is at variance with a previous suggestion (Falvey and Hengmichai 1978). Curves showing the increase in *Imperata* with increasing distance from the village show a slightly different shape, indicating that weed species other than *Eupatorium* may be involved in some instances. However, the proportion of ground cover by *Eupatorium* indicates that it is the dominant weed. There did also seem to be a positive

Fig. 5. Mean percent Eupatorium ground cover within an area of 1 km from different villages where grazing of accessible sites has occurred for varying lengths of time.

correlation (although data are not presented) with the distances cattle were forced to move out to graze with time; as the years progressed, cattle found less edible pasture in the areas closer to the village.

The simple correlation coefficients calculated from data at Pa Kia also indicate that the principal factors related to *Eupatorium* invasion are distance, grazing pressure, and years of sustained grazing. As distance is actually related to grazing pressure, it can possibly be eliminated in this discussion. The highly significant relationships between the product terms of "number of years grazed" and terms related to stocking pressure, in particular, the subjective term "estimated average stock numbers per year" indicate further that these factors may be the principal ones relating to *Eupatorium* invasion. Other variables that have been suggested (Falvey and Hengmichai 1978), such as topography, altitude, and soil type, seem to be less important with respect to invasion of *Imperata*.

It is possible to speculate on the role of *Eupatorium* in the changing environment of highlands of northern Thailand in the light of these data and other work. *Imperata*, which often populates deserted swidden sites and is maintained by annual fires (Iven 1975), can easily become dominated by *Eupatorium* species under moderate rates of grazing pressure. Until recently, removal of villages when cropping sites are less easily found has meant that animal production may not have suffered greatly. It is worthy of note that in these circumstances *Eupatorium* invasion was not the prime reason for village removal as it apparently has been in other countries (Holm et al. 1977). The abandoned sites, then populated by *Eupatorium*, which spreads over the deserted house sites and roads also, would be much less fire prone than *Imperata* and could thus provide an environment suitable for forest regeneration. In the more tropical environment of Indonesia, Eussen and Wirjahardja (1973) have noted that *E. odoratum* can form the first stage from *Imperata* dominance to secondary forest. As the forest becomes established, the shading effect of trees would lead to a decrease in vigour of the *Eupatorium* due to its high requirement for light (Ivens 1975), and eventually to complete or near complete disappearance of *Eupatorium*.

Increased land pressure in the highlands of north Thailand has rendered the previously useful *Eupatorium* phase a liability, because villages may not have the old option of moving. Thus *Imperata* pastures can be lost and animal production suffer because, although *Imperata* is not commonly viewed as a valuable pastures species, it is of value to the present grazing industry and will most probably remain so even with the advent of improved pastures (Gibson and Andrews 1978) and supplementary feeding (Falvey and Mikled 1978). The data provided in this paper, while not complete, do provide greater insight into the problem now being faced in the rangeland grazing industries of the highlands of north Thailand.

Literature Cited

- Auld, B.A., and P.M. Martin. 1975. The autecology of *Eupatorium adenophorum* Spreng. in Australia. *Weed Res.* 15:27-31.
- Eussen, J.H.H., and S. Wirjahardja. 1973. Studies on alang-alang (*Imperata cylindrica* (L.) Beauv.) vegetation. BIOTROP Bull. No. 6, Reg. Centre Trop. Biol., Bogor, Indonesia.
- Falvey, L. 1977. Ruminants in the highlands of northern Thailand—an agrosociological study. Thai-Australian Highland Agronomy Project, Tippiantre Press, Thailand. 124 p.
- Falvey, L., and P. Hengmichai. 1978. Native pastures in the highlands 2. Invasion of blady grass pastures by *Eupatorium* species. Third report of the Thai-Australian Highland Agricultural Project, Faculty of Agriculture, Chiang Mai University, Thailand. 107 p.
- Falvey, L., and C. Mikled 1978. Dry season supplementation of cattle in the highlands of northern Thailand. *Proc. Aust. Soc. Anim. Prod.* 12:175.
- Falvey, L., P. Hengmichai, and P. Hoare. 1978. Productivity of cattle grazing native highland pastures. *Thai J. Agr. Sci.* (in press).
- Gibson, T. 1976. First report of the Thai-Australian Highland Agronomy Project. Aust. Dev. Assistance Agency. 134 p.
- Gibson, T.A., and A.C. Andrews. 1978. Pasture agronomy research in northern Thailand highlands. *Proc. Aust. Soc. Anim. Prod.* 12:203.
- Holm, L.G., D.L. Plucknett, J.V. Pancho, and J.P. Herberger. 1977. *The World's Worst Weeds*. University of Hawaii Press, Honolulu. 609 p.
- Ivens, G.W. 1975. Studies on *Imperata cylindrica* (L.) Beauv. and *Eupatorium odoratum* (L.) Agr. Res. Council, Weed Res. Org., Begbroke Hill, Oxford.
- Magadan, P.B., E.Q. Javier, and J.C. Madamba. 1976. Beef production on native (*Imperata cylindrica* (L.) Beauv.) and Para grass (*Brachiaria mutica* (Forsk.) Stapf.) *Proc. 12th Int. Grass Cong.*, Moscow: 370-378.
- Mikled, C. 1977. Dry season supplementation of cattle grazing native grasslands in the north Thailand highlands. *Thai Agr. Sci.* 10:135-142.

Increase Forage Production Plant PERMA-PEL Range & Pasture Mixes

Depend on Ramsey Seed — long a leader in range improvement programs — for the finest clover, sub-clover, and grass seed mixes. Ramsey provides 3 general mixes for varying rainfall and soil conditions . . . plus special mixes for special situations. Introduce your range improvement program to Rhizo-Kote® and Nutri-Kote®. The seed coatings that provide a controlled germination zone, aids seedling establishment, and offers optimum rhizobia viability for root nodulation of legumes.

Write or phone for seed mix quotes (and for a free range seeding brochure)

RAMSEY SEED, INC.

P.O. Box 352, Manteca, CA 95336 (209) 823-1721