Studies on the invasion patterns of alien croftonweed and its impacts on the local ecosystem and communities in Liangshan Yi People Autonomous Prefecture (LYPAP)

Changjie Zhao

2010

Suggested Citation:
Zhao, J., Meng, X., 2010, Studies on the invasion patterns of alien crofton weed and its impacts on the local ecosystem and communities in Liangshan Yi People Autonomous Prefecture (LYPAP). Report submitted to Rufford Small Grant.

CONTENTS

1. Acknowledgements

We thank Rufford Small Grant (RSG) for providing the first financial support.

We would like to acknowledge our gratitude to all those who have been helping us in this study in Liangshan Yi People Autonomous Prefecture, Sichuan Province of China. This survey would not have been possible without the help and support of a number of people to whom we owe a great debt. Many thanks to the officials and staff from the LYPAP Bureau of Grasspand such as Heping, Chen Li., Jiasha Rebu, Liu Yong, He Zhila, Bai Chunhai, Liu Rui, and the Branch Bureau of Grasspand in every counties of LYPAP. Our special thanks to Jianlin Liu and Yang Hong for their encouragement and suggestion in field surveying. We express our thanks to Ms Azhi Ayue, for taking an interest and providing immense help for the surveys.

Moreover, special thanks to undergraduates and graduates of Central University for Nationalities and Xichang Normal University, who participating into the whole or periodic stages of this study.

Fig. 1.1 Native Rhesus monkey (Macaca mulatta) in the habitat invaded by Croftonweed in LYPAP

2 Summary

Under the RSG funding, this study was conducted in LYPAP of southern China. The aim of this project was to study the invasion patterns of alien crofton weed (Eupatorium adenophorum), and its ecological, social and economical impacts in Liangshan Yi People Autonomous Prefecture (LYPAP) of Southwest China. Through extensive sampling in the invaded areas, the diversity index of native species (mainly plants) was calculated to quantify the ecological impacts. Moreover, habitat sampling was conducted to decide the characteristics of invaded habitats and the most important influencing variables. Furthermore, through social-economical surveying, the social and economical impacts of invasion upon the local communities was quantified.

The invasion pattern of Croftonweed was surveyed in every counties, in which the same transect sampling method was utilized. On the bases of the sampling result, the invaded area was estimated and the total invasion pattern was determined. In total, there was 612386 hm² invaded by croftonweed, which accounted for 10.11% of LYPAP.

In habitat sampling, the potential influencing ecological variablews, for example elevation and water distance dispersion, were be quantified and recorded to determine the characteristics of invaded habitat in this alien species. Results showed that all the ecological message included in those variables could be decided by three most principal factors, ie. “Factor of General Ecological Characteristics”, “Factor of Damp and Light” and “Factor of Botanic Biodiversity ”. In principal, the occurring frequency of crofton weed will be related to 11 ecological factors as “Elevation”, “Landscape” etc.

Fig.2.1 Invaded croftonweed on the wall

Invasion of croftonweed has imposed huge deleterious impacts on the local ecosystem and minority communities. To determine the usful measures to control the invasion of croftonweed, all the controlling methods was explored, which included the chemical control, Mechanical control, Manual control and biological control, hoever, crofton weed could be perished effectively by one single way because of complex topography, climate type and big flexibility of weed itself, and the integrative including all the above controlling method should be utilized.

Fig.2.2 Invaded croftonweed in artificial forests

3. About Croftonweed

Croftonweed (*Eupatorium adenophorum*) (Fig 3.1) is a many-stemmed erect perennial shrub native to Mexico (Papes and Peteron, 2003) that has invaded more than 30 countries (Qiang,1998; Lu and Ma 2004). It invaded China in the 1940s from Burma and is now widespread in southwest China, where it has crossed southwest Sichuan Province, including Liangshan Yi People Autonomous Prefecture (LYPAP), which was the working site of this project (Fig.3.1).

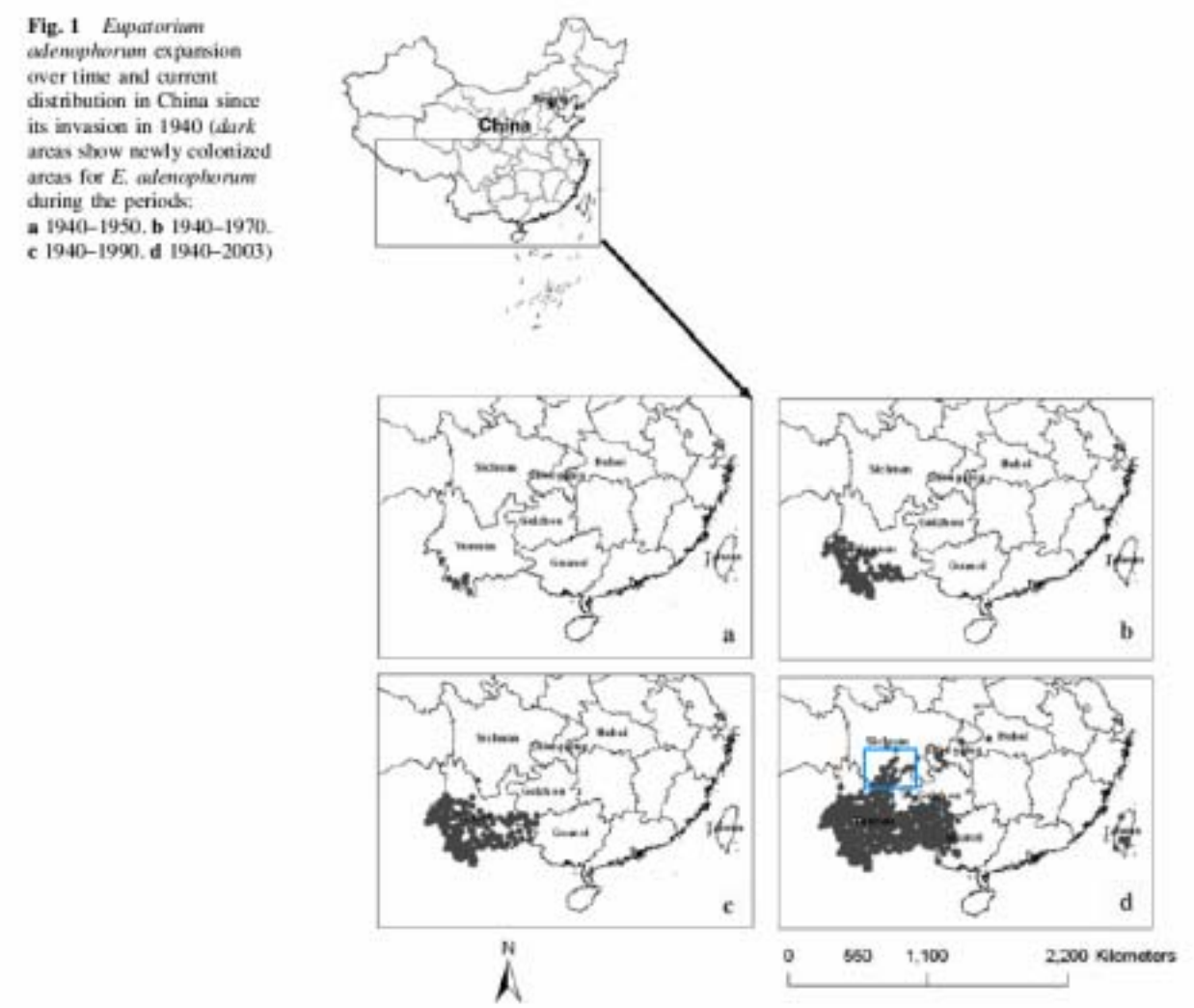

Fig. 1 *Eupatorium adenophorum* expansion over time and current distribution in China since its invasion in 1940 (*dark* areas show newly colonized areas for *E. adenophorum* during the periods: **a** 1940–1950, **b** 1940–1970, **c** 1940–1990, **d** 1940–2003)

Fig.3.1 Croftonweed invasion pattern in southern China (Sang *et al.*, 2010)

Its high reproductive capacity and windborne seeds are particularly adapted to colonizing bare or intermittently bare areas which make croftonweed a troublesome weed of crops, plantations, and pastures in many parts of the world (Wang et al. 1997). Since its invasion, croftonweed has spread rapidly across southwest China causing great economic losses in both cropland and rangeland (Liu et al. 1985), and the invasion intensity in LYPAP was very heavy.

Fig.3.1 Croftonweed (*Eupatorium adenophorum*) (Photo by Zhao)

Fig.3.21 Croftonweed seed

Fig.3.3 Root-set and stem-set of one cluster

4. Study area

4.1 Geographic information

This RSG project was conducted between Oct. 2008 to Dec. 2009 in Liangshan Yi People Autonomous Prefecture (LYPAP), Sichuan Province of China. As showed in Fig. 4.1., LYPAP locates in the southwestern Sichuan Province (E 100°03′-103°03′, N 26°03′-29°18′) and cover approximately 60000 sq km., in which there are 16 counties and 1 city, ie Xichang.

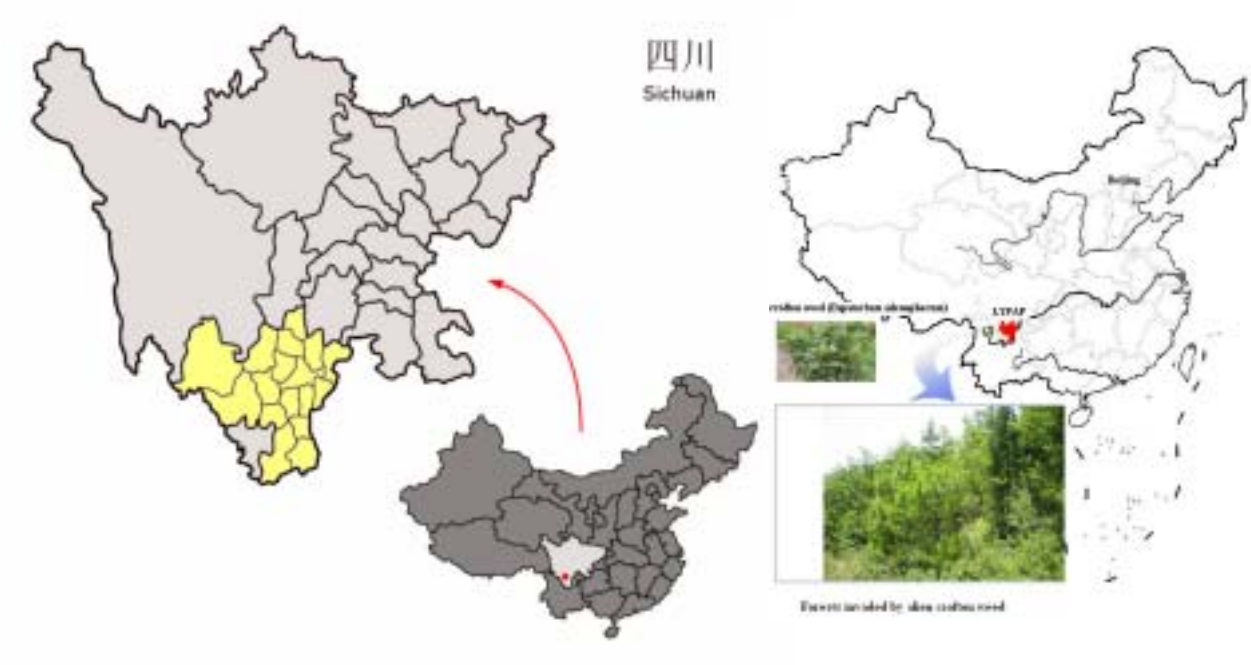

Fig.4.1. Liangshan Yi People Autonomous Prefecture (LYPAP), Sichuan Province of China

The LYPAP is the biggest Yi People area, where there are over 2 million Yis in the Liangshan Yi Autonomous Prefecture, which holds the single largest Yi community in China (Fig.4.2 and Fig. 4.3).

The LYPAP are rich in natural resources. The Jinsha River running through this area. The Yi areas are not only rich in coal and iron, but are also among China's major producers of non-ferrous metals. LYPAP abound in dozens of mineral resources, including gold, silver, aluminum, manganese, antimony and zinc. Vast forests stretch across the Yi areas, where Yunnan pine, masson pine, dragon spruce, Chinese pine and other timber trees, lacquer, tea, camphor, kapok and other trees of economic value grow in great numbers. The forests teem with wild animals and plants as well as pilose antler, musk, bear gallbladders and medicinal herbs such as poris cocos and pseudoginseng.

Fig.4.2 Typic mountainous environment in LYPAP

Fig.4.3 The local Yi Building

2.2 Biological Diversity

LYPAP is one of the international biological hotspots regions. This region supports a wide array of habitats including the most endemic-rich temperate flora and fauna in the world. The giant panda (*Ailuropoda melanoleuca*) (Fig.4.4), red panda (*Ailurus refulgens*) (Fig.4.5), *Capricornis sumatraensis (*Fig.4.6 *) and Lophophorus lhuysii (*Fig.4.6*). Moreover, LYPAP is one of the origin area of Fig.4.8 Metasequoia glyptostroboides* (Fig.4.7) and the *dove-tree* (Fig.4.8*).* Generally speaking, the fundamental construction, illegal hunting, overgrazing, and wood gathering are the primary threats to biodiversity in this LYPAP region.

Fig.4.4 Giant panda (http://www.huizhou.cn)

Fig.4.5 Red panda (www.wwfchina.com.cn

Fig.4.6 Capricornis sumatraensis (www.hudong.com)

Fig.4.7 Lophophorus lhuysii (http://m.laizhouba.net)

Fig.4.8 Metasequoia glyptostroboides (www.taibai.org)

Fig.4.9 Dove-tree (epaper.syd.com.cn)

5 Invasion intensity in LYPAP

(Note: This part was finished with the valuable help from Heping and many fundamental officials in the Bureaus of Husbandry in every counties.)

The invasion pattern of Croftonweed was surveyed in every counties, in which the same transect sampling method was utilized. On the bases of the sampling result, the invaded area was estimated and the total invasion pattern was determined. In total, there was 612386 hm² invaded by croftonweed, which accounted for 10.11% of LYPAP.

Tab.5.1 The invasion pattern of croftonweed in LYPAP

Cunty	**Total area(hm²)**	**Invasion area (hm²)**	**Invaded villages**	**Villages without croftonweed**	**Latitude**
Xichang	263407	116483	37	0	
Dechang	228422	66218	23	0	
Puge	193464	38482	23	11	
Lingnan	167015	42065	25	0	
Huili	452533	69263	48	1	
Huidong	322662	48567	53	0	
Zhaojue	269333	9769	4	43	
Butuo	168230	8439	9	21	
Leibo	294300	1319	25	24	
Meigu	273167	4721	15	21	
Yanyuan	840000	82255	14	20	
Muli	1325298	4523	21	6	
Jinyang	158760	10200	23	11	
Ganluo	215385	3485	15	13	29°27′
Xide	220200	42604	17	7	
Yuexi	224200	7200	35	5	
Mianling	442276	56793	37	1	
Total	6058652	612386	424	184	

6. Habitat preferences and utilization of croftonweed

The variables and the definition established in other studies (Dueser and Shugart, 1978) were utilized to quantify and record the integrative characteristics of croftonweed habitat, however, the necessary changes were made to let the method system adapt to croftonweed habitat surveying.

During field surveying, when croftonweed was spotted, a sampling plot (20X20 M^2) (Fig.6.1) would be designed and the variables would be quantified and recorded. Collaborated with the local guide and fundamental officials, several researchers quantified the related ecological variables and recorded the data in the forms prepared in advance, and the recording is as detailed as we can (Tab.6.1). The recorded data would be recorded in the habitat tables prepared before habitat surveying (Fig.6.2. and Fig 6.3).

In Xichang, Yuexi and Puge County, which have been the earliest and most serious area on croftonweed invasion, 398 plots (20 m × 20 m) were established, and the number of plots was balanced by land utilization, geographical situations, and invasion situation of croftonweed.

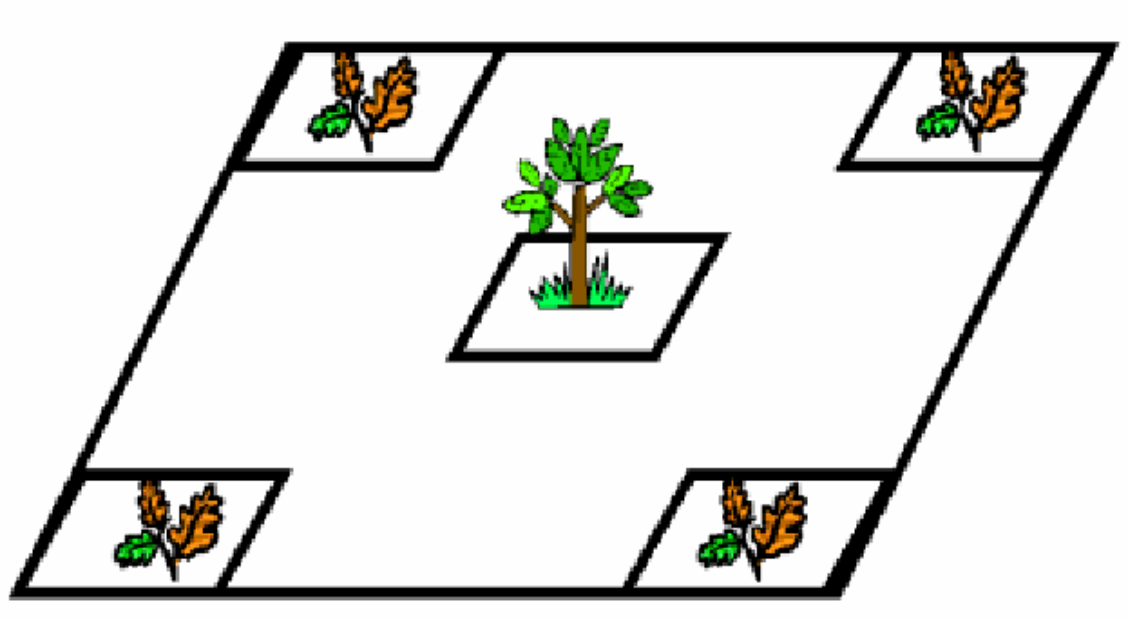

Fig.6.1 Random sampling plot scheme

Tab.6.1. The variable and the definition of the habitat surveying of croftonweed

Variables	**Definition**
Elevation (m)	The elevation at the core area of the plots.
Slope aspect	Aspect of the plot, four categories: east-facing (45–135°), south-facing (135–225°), west-facing (225–315°), and north-facing (315–45°).

Slope degree	Slope of the plot, from 0° to 90°; every 10° is a category.
Slope position	Position of the plot on the hillside in three categories: upper (>2700 m), middle (2000~2700 m), and lower (<2000 m).
Canopy	Canopy of overstory vegetation in the 400 square plot.
Vegetation type	Six categories: mixed evergreen and deciduous broadleaf forest, mixed conifer and broadleaf forest, conifer forest, shrub, grassland, and bare land.
Croftonweed cluster	Average number of Croftonweed in the plots.
Croftonweed height (cm) :	Average height of Croftonweed in the plots.
Arboreal DBH (cm)	Average diameter at breast height (DBH) of the trees nearest the center in each plot
Tree density	Average number of trees in two 20-m2 rectangular transects
Arboreal dispersion (m)	Average distance to the trees nearest the center in each plot
Shrub density	Average number of shrubs in plots.
Shrub size (cm)	Average DBH of the shrubs nearest the center in each plot
Shrub dispersion (m)	Average distance to the shrubs nearest the center in each plot
Grass proportion (%)	Proportion of herb-cover area in the plot
Water-source dispersion (m)	Estimated straight-line distance from the sampling plot to the nearest water source
Open-land proportion (%)	Proportion of land area without croftonweed cover in the plot.

RSG-Studies on the Croftonweed invasion in LYNP

四川省凉山州紫茎泽兰(*Ageratina adenophorum*)入侵调查

Fig.6.2. Surveying of General Information on croftonweed invasion

RSG-Studies on the Croftonweed invasion in LYNP

四川省凉山州紫茎泽兰(*Ageratina adenophorum*)入侵调查记录表

样地号								
海拔（m）								
坡向								
坡度								
土壤湿润度								
山形								
林型								
样地	种数							
植物	株数							
紫茎	平均株高							
泽兰	株数							
乔木高度								
乔木大小								
灌木高度								
灌木数								
杂草高								
杂草高度								
乔木凋落量								
灌木凋落量								
生长期（叶/花）								
备注								

Fig.6.3. Variable recording in croftonweed plot

Fig.6.4. Croftonweed plot in shrub

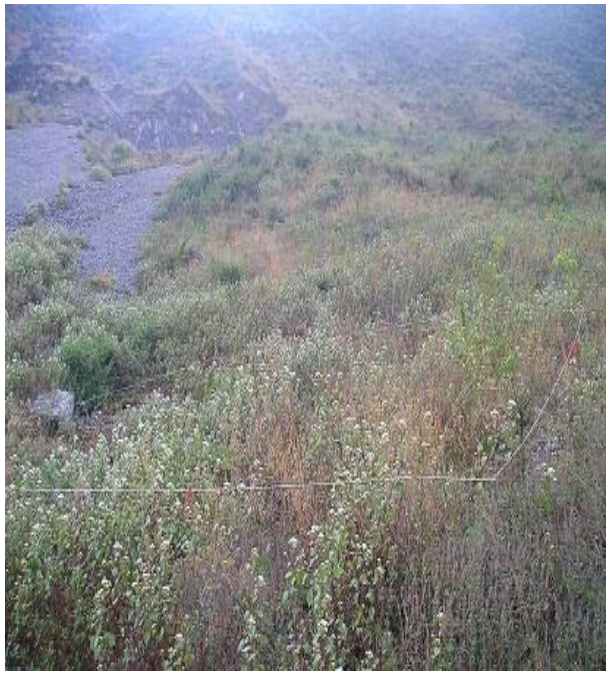

Fig.6.5. Croftonweed plot in mine site

During the field studying, three to five members will collaborative peoples (Fig.6.6 and Fig.6.7), officials and guides,

Fig.6.6. Member working in the habitat plot

Fig.6.7. Member working in the habitat plot

In total, 398 habitats were surveyed and the in which every variables was quantified and recorded. All the collected quantified habitat data was managed and analysed, and the results showed that: 1, The different invasion stages were existed in the croftonweed invasion, in which the height of invaded croftonweed was from 16mm to 240 cm (n=398) with the average 77.58cm (Fig.6.8-Fig.6.11). Moreover, the distribution dentist was 1-410 cluster in plots with the range from 1-410 cluster and the average 46.34±8.96 (n=398).

Fig.6.8. Croftonweed in artificial forest

Fig.6.9. Croftonweed in building sites

Fig.6.10. Croftonweed in farmland

Fig.6.11. Croftonweed in local natural site

Data analyses were done with SPSS 11.0, and the appropriate statistic methods were utilized to explore the potential differences in habitat selection of croftonweed, and PCA (Principal Component Analysis) was used to decide the main influencing factors which impose the important impacts upon the habitat utilization of croftonweed in LYPAP.

As showed in Tab. 6.2 and Tab. 6.3, the croftonweed summer habitats principal components factor analysis showed that Elevation, Slope degree, Ground water,Trees type, Shrub number, Grass cover,Farmland dispersion,Slope aspect,Water dispersion, Plant species, and the Plant numbers were the main seven factors to decide the habitat selection of croftonweed in LYPAP. Combined with the realistic surveying in the field, we found that all the above differences could be ontegrated into such three ecological factors as Environmental factor, Light-water factor and the Plant diversity factor (Tab.6.4).

Tab. 6.2. Total variance of the ecological variables of croftonwed

Component	Total	% of Variance	Cumulative %
1	8.568	57.117	57.117
2	2.827	18.845	75.962
3	2.337	15.583	91.545
4	0.725	4.831	96.376
5	0.499	3.324	99.700
6	4.507E-02	0.300	100.000
7	6.077E-16	4.051E-15	100.000
8	4.915E-16	3.277E-15	100.000
9	3.287E-16	2.191E-15	100.000
10	1.869E-16	1.246E-15	100.000
11	1.110E-16	7.401E-16	100.000
12	4.894E-17	3.263E-16	100.000
13	-1.117E-16	-7.449E-16	100.000
14	-4.618E-16	-3.078E-15	100.000
15	-1.074E-15	-7.160E-15	100.000

Tab.6.3. Component Matrix of the Ecological Facts of croftonwed

Variable	**Component**		
	Component 1	**Component 2**	**Component 3**
Elevation (m)	0.993	2.714E-02	5.034E-02
Slope aspect	-0.182	0.843	-0.402
Slope degree	-0.993	-5.539E-02	-3.726E-02
Ground water	0.993	5.539E-02	3.726E-02
Trees type	-0.957	-0.269	6.382E-02
Species in the plot	-0.192	5.095E-02	0.944
Number of other plants	0.173	0.446	0.853
Arboreal height	-0.640	0.579	0.309
Arboreal DBH	-0.745	0.200	0.441
Shrub height	-0.132	0.728	-1.633E-02
Number of shrub	0.910	0.336	0.195
Grass height	0.890	-0.266	0.257
Grass cover	0.993	5.539E-02	3.726E-02
Water-source dispersion (m)	-0.149	-0.861	0.389
Farmland-source dispersion (m)	0.993	5.539E-02	3.726E-02

Tab. 6.4. Components grouping and naming of the ecological facts of croftonwed

Component	Principal Variables and means	Fact Naming	% of Variance
1	Elevation (1644.08±110.92, n=76) Slope degree (1.43±0.68, n=76) Ground water(3.13±0.64, n=76) Trees typr (4.03±2.84, n=76) Shrub number (12.82±2.12, n=29) Grass cover (1.58±1.36, n=67) Farmland dispersion (0.42±0.08, n=31)	Environmental factor	57.117%
2	Slope aspect (104.18± 90.27, n=76) Water dispersion (0.74±0.09, n=61)	Light-water factor	18.845%
3	Plant species (5.96±2.97, n=76) Plant numbers (179.6±16.9, n=76)	Plant diversity factor	15.583%

For the invaded croftonweed in LYPAP, the current preferred croftonweed is 1500~1700, however, croftonweed could distribute as high as 2500 m (Fig 6.12~6.14). Moreover, our results showed that the croftonweed rich in farmland and other environment with artificial activities (Fig 6.15~6.17).

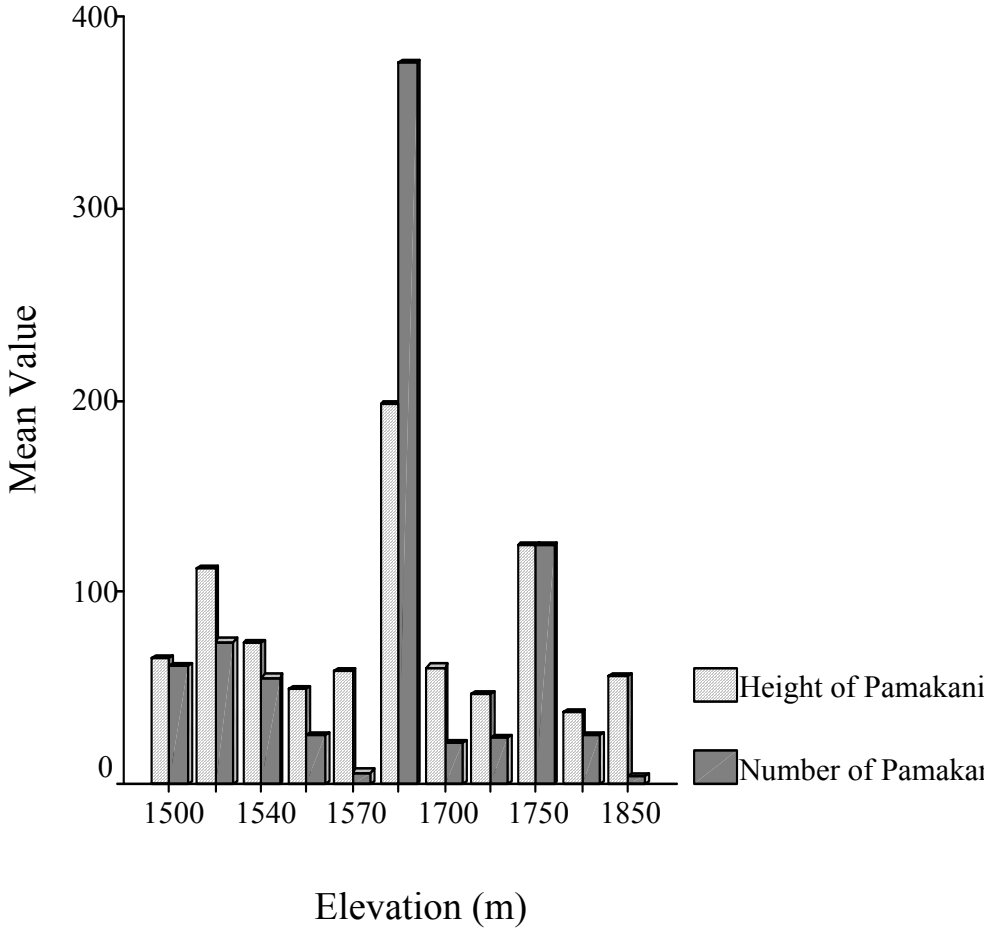

Fig.6.12. The number of the crofton weeds and elevation

Fig.6.13. Croftonweed at elevation of 2532 m

Fig.6.14. Croftonweed at elevation of 1020 m

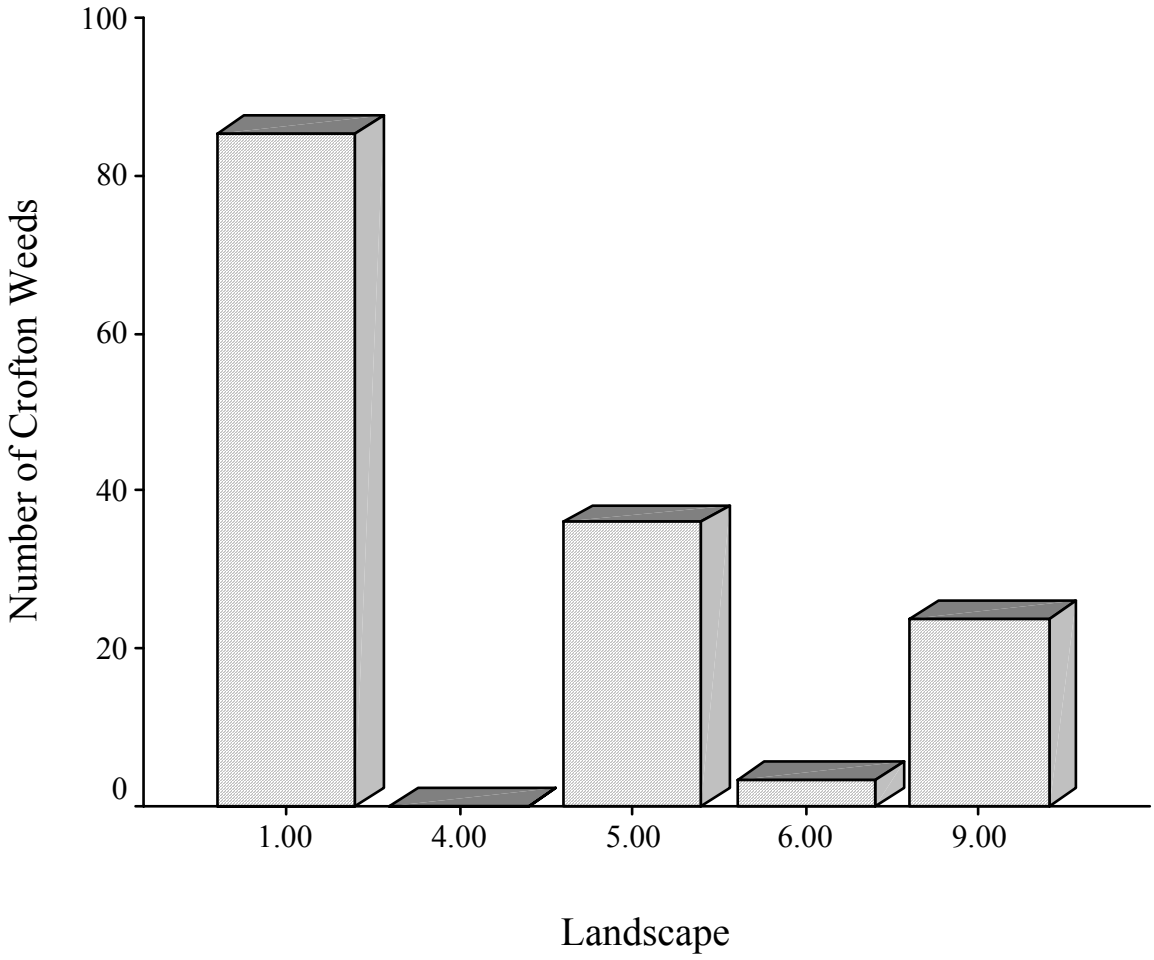

Fig.6.15. The number of the crofton weeds and landscape

Fig.6.16. Croftonweed in deserted farmland

Fig.6.17 Croftonweed in farmland and pond

Furthermore, our results showed that croftonweed prefer the north and west slopes, and the height growth increased with the lower of light intensity, which differed from other researchers' report (Sun et al., 2006) (Fig 6.18~6.20) and should be related to the different researching regions.

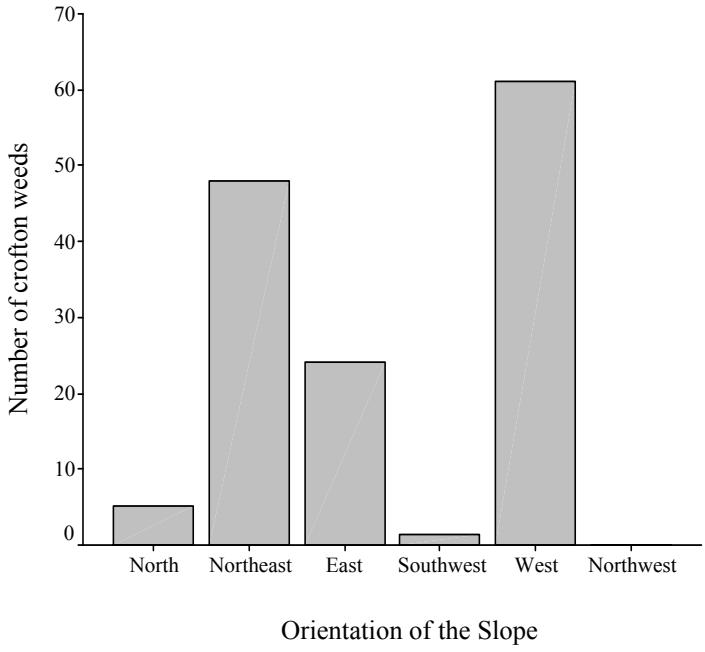

Fig.6.18. The number of the crofton weeds and the orientation of the slope

Fig.6.19. Croftonweed in sunned slope

Fig.6.20. Croftonweed in shaded slope

Furthermore, this study showed that croftonweed prefer habitat with shorter distance from water, therefore, in watery environment which generally related to the artificial activities such as farming, the croftonweed abound in (Fig 6.21~Fig 6.22).

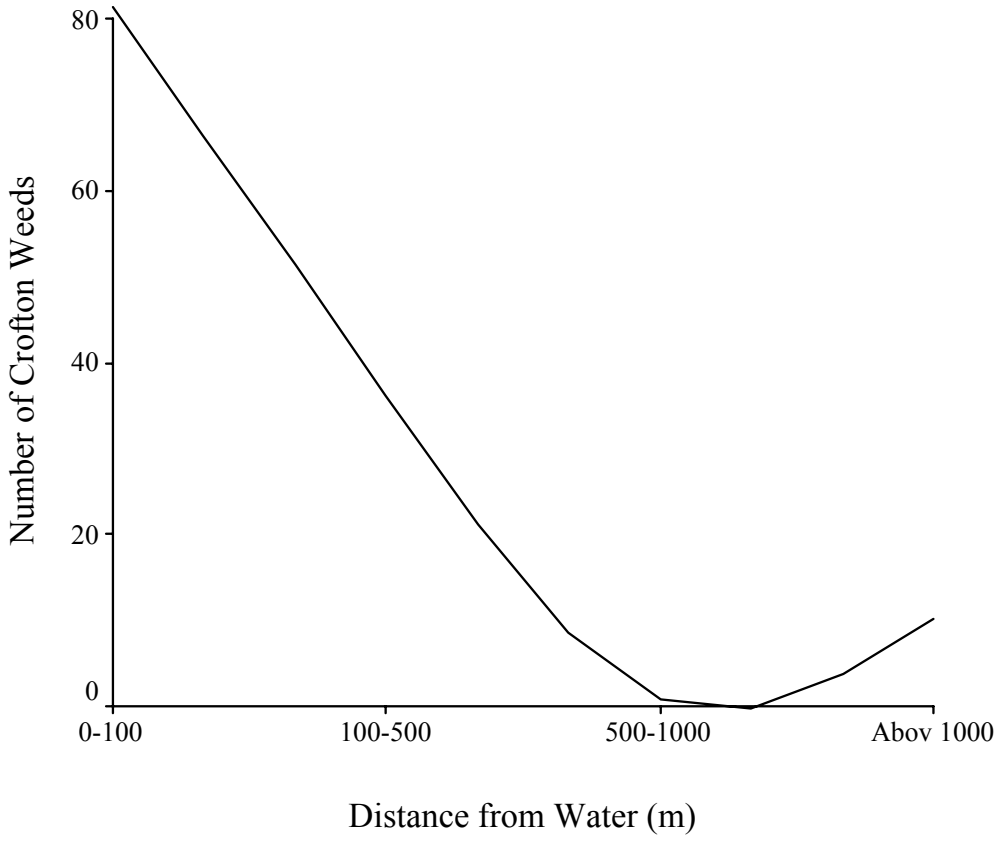

Fig.6.21. The number of the croftonweed and distance from eater source

Fig.6.22. Watery environment of croftonweed

Furthermore, this study showed that, as a alien species, croftonweed interact with the native plant species during the invasion process. At the beginning of invasion, native species could co-exist with invaded croftonweed, but in the prime invasion, the habitat will became the mono-species environment and only croftonweed existed (Fig.6.23~Fig.6.25).

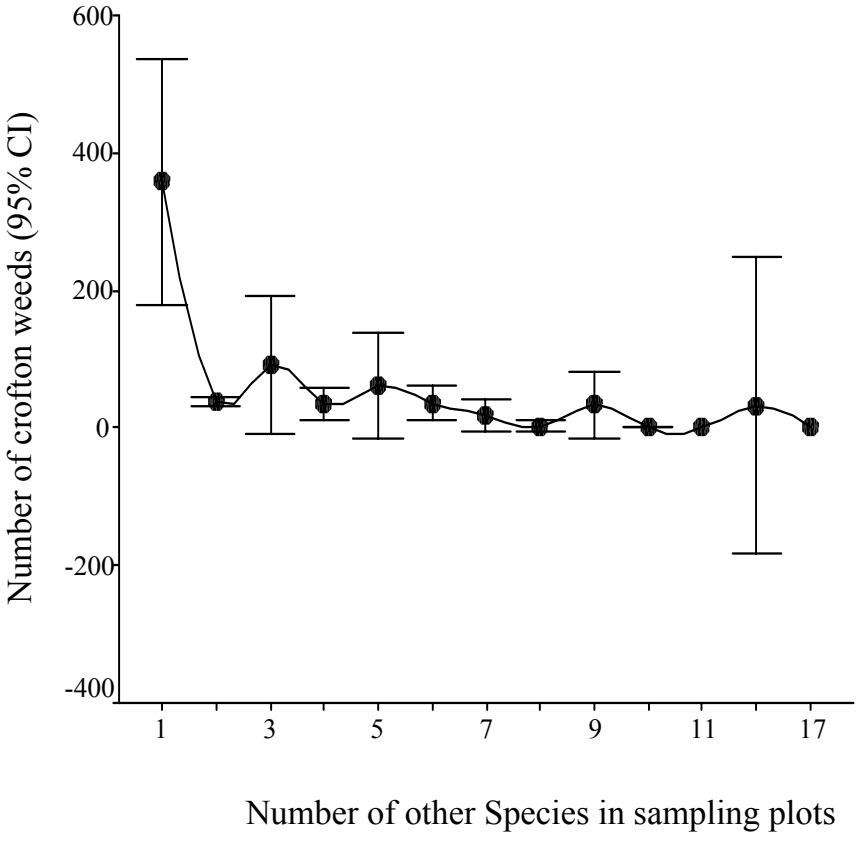

Fig. 6.23. The number of the crofton weeds and Number of other Species in sampling plots

Fig. 6.24 Beginning of the invasion

Fig. 6.25 prime period of the invasion

As showed in Tab.6.5, the croftonwed in different habitat grows differently, in which the croftonweed habits in the farmland and other artificial environment was the best growing pattern, which was higher and with higher dentist (Fig. 6.26-Fig.6.29).

Tab.6.5 Relation between the landscape and the number and height of Pamakani

Landscape	**Croftonweed**	**N**	**Mean**	**SE**
Farmland	Number	30	85.2333	11.8921
	Height	23	110.2783	55.1788
Conifer-broaded forest	Number	15	36.0000	25.7411
	Height	12	57.0833	17.6663
Conifer	Number	14	3.5000	1.8408
	Height	8	43.9375	14.7469
Deforested slope	Number	10	23.7000	11.7054
	Height	9	51.2556	20.9358

Fig. 6.26 Croftonweed in the deserted build site

Fig. 6.26 Croftonweed in artificial forest

Fig. 6.27 Croftonweed in local village

In LYPAP, the roads and streams are important conduits for the spread of croftonweed (Fig 6.28-6.31), which was supported by other researchers' results (Lu and Ma 2004, 2006).

Fig.6.28 Croftonweed spread along river

Fig. 6.29 Croftonweed spread along road

Fig.6.30 Croftonweed along the railway

Fig.6.31 Croftonweed along the flooded river

Fig.6.31 Croftonweed in the farm land

Fig.6.31 Croftonweed along irrigation ditch

7. Deleterious biological impact from the croftonweed invasion

(Note: This part was finished by Li Hui, one undergraduate in Central University for Nationalities)

To explore the potential influence of croftonweed on the seed germination of other plants, we made the co-exist challenging bourgeoning experiment, and the relationship between E. adenophorum and *Lolium perenne* and the effects on seed germination of other plants were studied by the experiments of seed germination and young seedling growth, and the measuring of second metabolism materials.

The results showed the increase of germinating rate, seedling rate and root growth of L. perenne were more obvious than those of E. adenophorum in the germinating experiments with different percentage of seed numbers (Fig.7.1). The second metabolites of E. adenophorum and L. perenne included tannins and total flavonoids. And the contents of two kinds of compounds were not different. But seedling growth of E. adenophorum was limited by the culture water of L. perenne. Seed germination of radish and wheat were restrained by using the culture water from both E. adenophorum and L. perenne. However, seed germination of two plants were different by using the diluent culture water. Seed germination of radish was also restrained and that of wheat was

stimulative (Fig 7.2~Fig.7.5). All these results could help us to know the biological mechanism of the deleterious impacts from the croftonweed, and could help to determine the appropriate plant to be acted as the supplant species when the biological controlling was conducted.

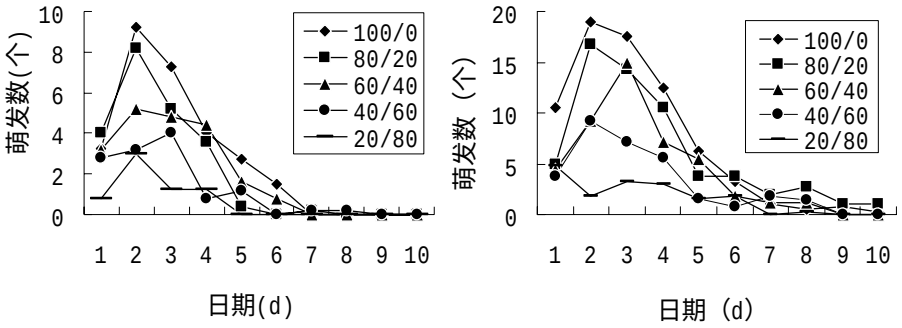

Fig.7.1 Fig.1 The germinating speed of E. adenophorumand L. perenne

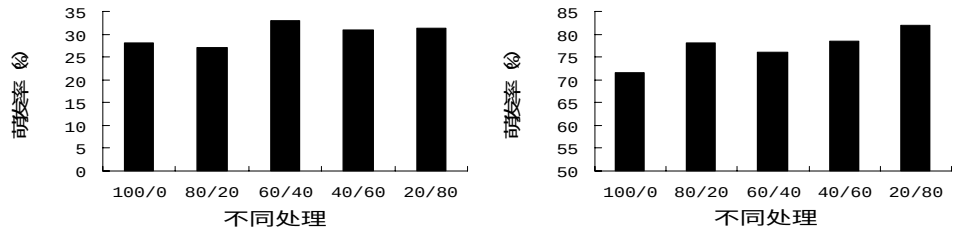

Fig.7.2 The germinating rate of E. adenophorum and L. perenne

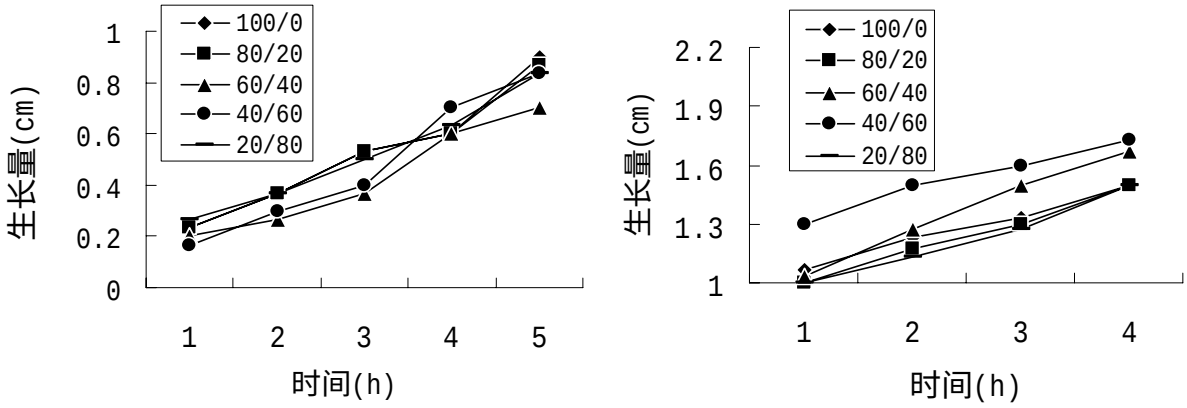

Fig.7.3 Root growth of L. perenne during during the Germination Stage and the Seedling stage

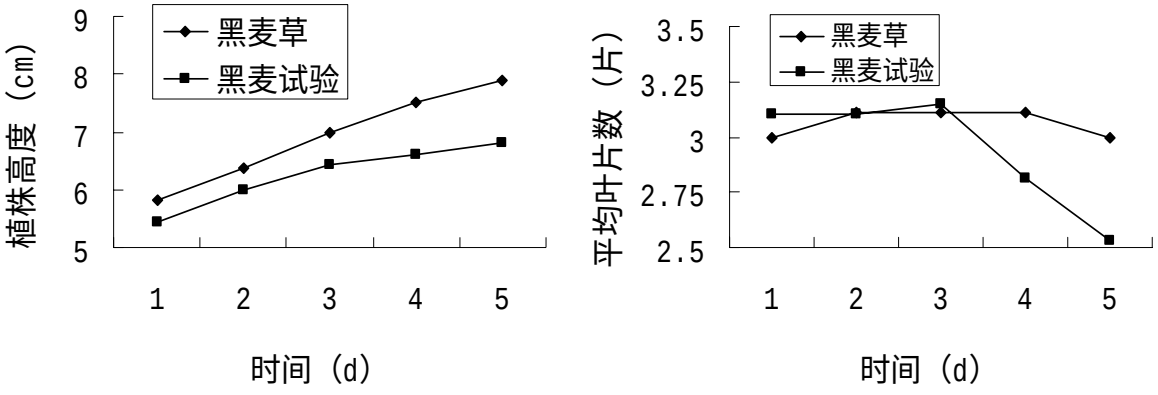

Fig. 7.4 The height variations and leaf variations of L. perenne in the culture water

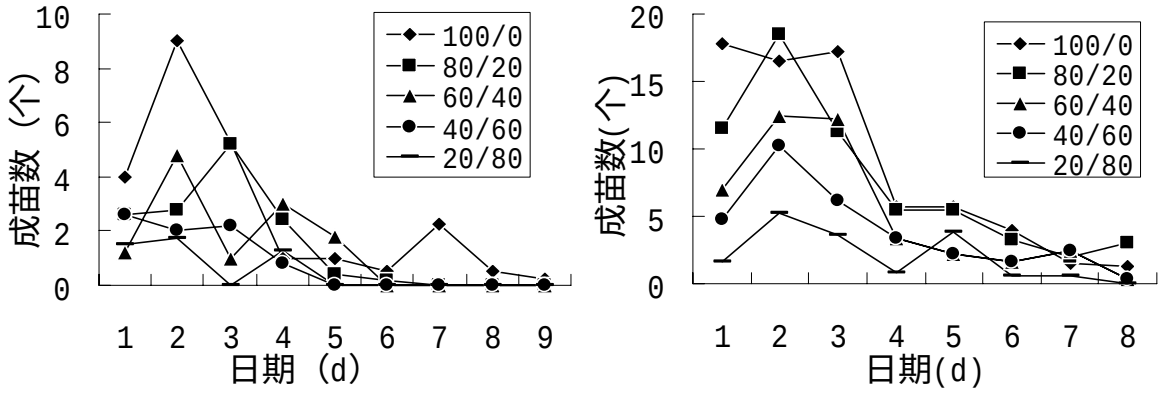

Fig.7. 5 The seeding speed of E. adenophorum and L. perenne

8. Social-economic impact from the croftonweed invasion

The economic impacts of invaded croftonweed was huge, and morethen 100 million Yuan a year would be spend in the controlling the croftonweed (correspondence with the local officials in Bureau of Grass) (Fig.8.1-Fig.8.4).

Fig.8.1 Croftonweed in farmland

Fig.8.2 Croftonweed near to local house

Fig.8.3 Croftonweed near to local house

Fig.8.4. Croftonweed in village

The outbreak of Crofton weed is associated with destruction of primary plant community, bare ground, and loose soil except its biological character. Therefore, crofton weed is advised to cover ground as the first step, then tall seedlings are used to afforest. It has positive significance in terms of water and soil conservation (Fig.8.5).

Fig.8.4. Croftonweed and the loose soil

9 Environment educating and publicizing in local communities

To improve the education level of the pupils and make them know the alien species and the potential damages, we entered into the local prime school and middle school, in which, the related knowledge was lectured by the team member (Fig.9.1). Moreover, several croftonweed experts were invited to lecture to the participated undergraduates and graduates in team (Fig.9.2).

Fig.9.1 Lecturing in school

Fig.9.1 Lecturing in the field

To improve the education level of the pupils and make them know the alien species and the potential damages, we entered into the local prime school and middle school, in which, the related knowledge was lectured by the team member (Fig.9.1). Moreover, several croftonweed experts were invited to lecture to the participated undergraduates and graduates in team (Fig.9.2).

Fig.9.3 Publicizing in local communities

Fig.9.4 Publicizing in local markets

Fig.9.5 Environmental education

Fig.9.6 The local environmental ***education***

Fig.9.7 One of the presentations

Moreover, we once made several presentations for the local communities, local authorities, Xichang Normal University and Central University for Nationalities (Fig.9.7). Through the environmental educating at the local school and communities such as the local markets, the problem existed in the local environmental and general education were known and the future educating strategies could be decided. Furthermore, We collected related data and analysed the information, and we composed an analyzing report (in Chinese) named "The status of croftonweed invasion and the potential controlling measures In LYPAP", which have been submitted to the local managing authority and the local communities.

10. Controlling of the croftonweed invasion

To determine the usful measures to control the invasion of croftonweed, all the controlling methods was explored, which included the chemical control, Mechanical control, Manual control and biological control.

Biological control

The tephritid gall fly (Procecidochares utilis) was introduced into Hawaii from Mexico to control Crofton weed in 1940s. Its biological character and its feasibility to deal with Crofton weed have been wildly studied. As the related experiment was conducted in Kunming,Yunnan Province, some flock of procecidochares utilis migrated into LYPAP and attack the local croftonweed, and the plant height and bud number are reduced and sexual productivity decreased in item of procecidochafes utilis (Fig.10.1), however only its seeding was influenced but no significant impact on the whole cluster of croftonweed. Alternative control way is based on the compete phenomenon among plants to control the growth of Crofton weed by occupying ecological niche with growth priority of one or more plants, for which, a series of experiments were conducted to testiy the potentiality and the system ***(Checked in above chapter "7. Deleterious biological impact from the croftonweed invasion")***.

Fig. 10.1 Croftonweed autoeciousnessed by Procecidochares utilis

Chemical control

Chemical control is suitable for single population of Crofton weed. The control result of spilling chemical remedy is influenced by season. The main compounding herbicides refer to the solution of chlorate sodium. Most herbicides only operate on the plant above ground while act hardly on the subterraneous root (Fig.10.2). Moreover, although some kinds of herbicides can be used to control Crofton weed effectively, the use of chemical control must be carried out wisely to avoid the possible negative effects to the environment.

Fig. 10.2 Died croftonweed with the upper parts owing to weedicide

Mechanical control and manual control

The mechanical such as tractor was used to control Crofton weed in some counties of LYPAP, and at the household level in village, the mattock can be used to dug out scattered plants of small area. Moreover, the manual control strategy was used in many counties, and the fundamental government and authorities organized farmers to dig out Crofton weed.

Although the above regular methods could reduce flowering, seed set, vigour and density of infestation of croftonweed, and the, however, there have been abundant seed in soil and strong asexual propagation of the plant, moreover, the invaded habitat is not even but very complex, e.g. steep slope, scattered edge of plough, sparse forest undertake. Thus, complex habitat confines mechanical control in fact (Fig.10.3).

Fig. 10.3 New growth of croftonweed after manual removal

11. Financial information

The Financial Information is provided as following (Tab.12.1). Under the RSG funding, we worked hard to collect data and publicize the results.

Tab. 11.1 The financial expending of project

Budgeting Items	**Budget**	**Actual Amount**
Fee for local guide: 5 £/day.guide×30day×10 guides	£1,500.00	£1,500.00
Travel in LYPAP for surveying (traffic renting and fuel	£2,000.00	£2,000.00
Public presentation and Visiting in Yi People household	£1,000.00	£1,000.00
Living provision and equipment such as raincoat, sleeping bag and camp	£500.00	£500.00
Return travel from Beijing to Xichang of LYPAP (2 persons)	£500.00	£500.00
Map purchasing	£500.00	£500.00
Total	£ 6, 000.00	£ 6, 000.00

12 Main references

Lu, Z., Ma, K., 2006, Spread of the exotic croftonweed (*Eupatorium adenophorum*) across southwest China along roads and streams. Weed Science, 54:1068–1072.

Lu, Z., Ma, K., 2004, The influence of topographical factors on the invasion of the alien species, *Eupatorium adenophorum*. Acta Phytoecologica Sinica. 28:761-767.

Papes, M. and A. T. Peteron. 2003. Predicting the potential invasive distribution for *Eupatorium adenophorum* Spreng. in China. J. Wuhan Bot. Res. 21:137–142.

Qiang, S., 1998, The history and status of the study on crofton weed (*Eupatorium adenophorum* Spreng.) a worst world-wide weed. Journal of Wuhan Botanical Research, 16: 366-372.

Sang, W., Zhu, L., Axmacher, JC, 2010, Invasion pattern of Eupatorium adenophorum Spreng in southern China. Biol Invasions. 12:1721–1730

Sun X, Lu Z, Li, Jianf Q., Lang, Z., 2006, Ecological adaptation of *Eupatorium adenophorum* populations to light intensity. Journal of Forestry Research, 17(2): 116–120.

Liu, L., et al., 1985, Studies on the distribution, harmfulness and control of *Eupatorium adenophorum* Spreng. Acta Ecologica Sinica, 1985, 5: 1-6.

LI Z, Xie, Y., 2002, Invasive Alien Species in Chin. Beijing: China Forestry Publishing House.