Pak. J. Bot., 39(7): 2519-2526, 2007.

PARTHENIUM INVASION IN PAKISTAN – A THREAT STILL UNRECOGNIZED

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Abstract

Parthenium weed (*Parthenium hysterophorus* L) an alien invasive weed species, is spreading throughout Pakistan. Worldwide, it has been designated as one of the most troublesome weed species. The adverse effects of this weed on human beings, livestock, crop production and biodiversity are well documented. Due to a lack of information on its spread in Pakistan since its invasion, a phytosociological survey with special reference to parthenium weed was carried out in Islamabad during August-October. 2002. Six main sectors of Islamabad were selected for sampling. The phytosociological survey of these sectors of Islamabad revealed a total of 30 weed species reported along with *P. hysterophorus*. The survey also showed a high relative frequency, relative density and importance value of *P. hysterophorus* in general, however, the percentage relative frequency of weed in these sectors ranged from 13.5% to 39.1%. This survey revealed that *P. hysterophorus* had an appreciable degree of sociability with *Senna occidentalis* (L.). Link, *Desmostachya bipinnata* L. Stapf., and *Lantana camara* L., in these sectors. Data on the association of *L. camara* with *P. hysterophorus* suggests that a transition phase of competition or succession is in progress between these two alien species. The population of many common medicinal plants growing in the wastelands of Islamabad may rapidly decline due to the aggressive colonization by Parthenium weed. The ever-increasing infestation of this weed in urban areas also poses a serious threat to the health of the inhabitants of Islamabad.

Introduction

Biological invasion by alien invasive species is now recognized as one of the major threats to native species and ecosystems. It produces severe, often irreversible impacts on agriculture, recreation and natural resources. Invasive species are a real threat to our environment and economy. These non-native plants and animals harm or endanger native plants and animals or other aspects of biodiversity. They have invaded almost every type of native ecosystem and caused hundreds of extinctions throughout the world (Joshi, 2000).

Parthenium hysterophorus Linn., (Asteraceae), an alien invasive species, commonly known as parthenium weed is an annual or short-lived ephemeral herb of neo-tropical origin that now has a pan-tropical distribution. In India and Australia, *P. hysterophorus* is considered to be a major weed (Mahadevappa 1997; Navie *et al*., 1996). In Pakistan, this weed is spreading aggressively in wastelands, degraded areas, rocky crevices, along water channels, roadsides and railway tracks. It has recently also been reported in cultivated lands (Shabbir, 2002). This noxious weed can affect crop production, animal husbandry, human health and biodiversity.

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The impact of *P. hysterophorus* on livestock production is significant, both directly and indirectly and affect grazing lands, animal health, milk and meat quality (Tudor *et al*., 1982; Chippendale, 1994), and the marketing of pasture seed and grain. More than two decades ago, some serious human health risks from *P. hysterophorus* were reported from India (Lonkar *et al.*, 1974). The initial symptoms of allergy caused through Parthenium contact are described as itching, redness, swelling and blisters on eyelids, face and neck, which then spread to the elbows and knees. In the later stages the skin thickens and darkens. The allergic reactions include hay fever, asthma or dermatitis and can be caused by the dust, debris or volatile fumes from the plant as well as its pollen (McFayden, 1995).

Because of its efficient biological activity and adaptability to varying soils and microenvironments, parthenium weed has a tendency to replace the dominant flora in wide range of habitats cutting across state boundaries and agro-climatic regions. Very little or sometimes no other vegetation can be seen in *P. hysterophorus* dominated areas. Wherever it invades, it forms a territory of its own by replacing the indigenous natural flora including medicinal herbs utilized by man as a source of medicine (Oudhia, 2000). Its allelopathic properties, which cause inhibition of germination and suppression of the natural vegetation including many medicinal herbs, pose a strong threat to biodiversity.

Most of the natural herbs of Islamabad are not equipped with the versatile characters that parthenium weed has, and as a result they cannot withstand close competition with it. Hence, their populations are steadily declining territories invaded by parthenium weed. The main objectives of this study were to collect phytosociological data on wastelands weeds in Islamabad, with special reference to parthenium weed invasion, and to study the threats posed by *P. hysterophorus* to the native flora including medicinal plants.

Materials and Methods

Parthenium hysterophorus is usually insensitive to photoperiod and thermoperiod but its growth rate is greatest during the rainy season. A phytosociological survey was conducted during the period of August-October, 2002. The survey was carried out in the main sectors of the capital. Islamabad is situated at Longitude 73^{o} to73^{o} $5.7^{/}$E and Latitude 33 $^{o}35^{/}$ to 33^{o} $45^{/}$N. During the survey all wild species growing along different wastelands and roadsides of these sectors were collected and identified by referring to *Flora of West Pakistan* by Stewart (1972), *The Flora of Punjab* by Ahmad (1980) and *Wild Flowers of Rawalpindi-Islamabad* by Nasir *et al*., (1987). Weed studies were made following the list count method suggested by Raju & Reddy (1998) using 50 x 50 cm quadrates. Importance Value (IV) is the sum of the relative density (RD) and relative frequency (RF) of species in a stand. Sampling was conducted randomly in all selected sectors of Islamabad. The compiled data was analyzed for quantitative and qualitative studies using following equations:

$$1.\ \text{Relative density (\%)} = \frac{\text{Absolute density for a given species}}{\text{Total absolute density for all species}} \times 100$$

$$2.\ \text{Relative frequency (\%)} = \frac{\text{Absolute frequency value for a species}}{\text{Total absolute frequency for all species}} \times 100$$

$$3.\ \text{Importance Value (IV)} = \text{Relative frequency} + \text{Relative Density}$$

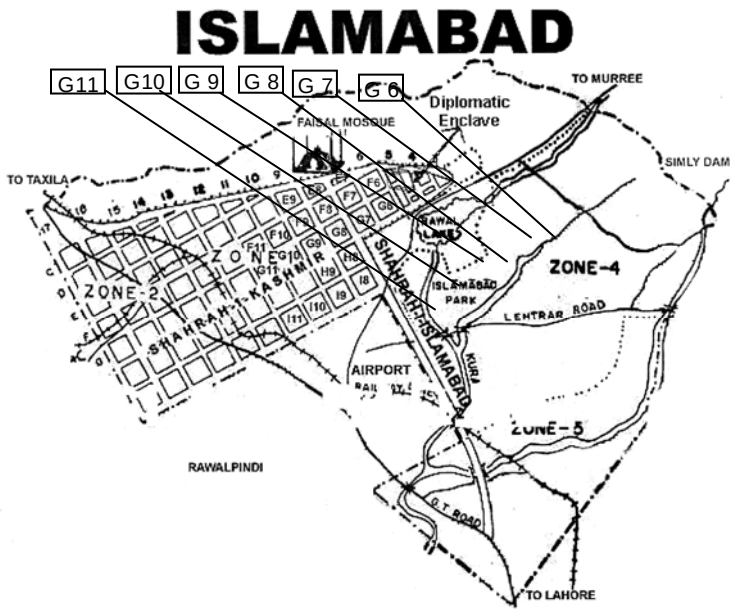

Fig. 1. Site map of Islamabad.

Results

The survey of selected sectors of Islamabad revealed a total of 30 weed species belonging to more than 13 angiosperm plant families that were associated with *P. hysterophorus*. Almost all the selected sectors of Islamabad had a heavy infestation of *P. hysterophorus*. Plants associated with *P. hysterophorus* in different sectors showed independent association, which over all reflect the herbaceous flora of the wastelands and roadsides of these sectors.

The analysis of the data collected from sector G-6 of Islamabad revealed that the weed *Parthenium hysterophorus* in this sector was accompanied by 9 other species of weeds. *P. hysterophorus* was the most dominant plant species with an importance value of 110% and relative density and frequency value of 77.8 and 32.1% respectively (Table 1). This was followed by *Achyrenthes aspera* L., with a value of 17.86% for relative frequency of occurrence.

The wastelands of sector G-7 were found to be least disturbed and minimum of human perturbation was recorded. The sector G-7 was inhabited by a high diversity of weeds, a total of 11 species were found in this sector. *Cynodon dactylon* was the most dominant weed species with the highest importance value i.e., (51.3), followed by *Desmostachya bipinnata*, with importance value of 35.4 (Table 1). *P. hysterophorus* had a frequent to occasional level of occurrence in this sector, but was significantly less frequent than the dominant grass species.

Sector G-8 exhibited a total of 10 plant species associated with *P. hysterophorus. Parthenium hysterophorus* was the most dominant weed species of this sector alongwith *Euphorbia prostrata* and *Cynodon dactylon* as co-dominant species. *Parthenium hysterophorus* had the highest relative frequency (28.1%) followed by *Euphorbia prostrata* (15.6%) and *Cynodon dactylon* (12.5%).

Table 1. Datasheet showing percentage relative frequency and density and importance values of weeds of wastelands of selected sectors of Islamabad.

S.No.	Weeds of Wastelands	R.F (%)						R.D (%)						I.V					
		G-6	G-7	G-8	G-9	G-10	G-11	G-6	G-7	G-8	G-9	G-10	G-11	G-6	G-7	G-8	G-9	G-10	G-11
1.	*Parthenium hysterophorus* L.	32.1	13.5	28.1	36.0	21.2	39.1	77.8	25.2	62.2	74.9	89.8	75.8	110	38.7	90.3	111	111	114
2.	*Lespedeza juncea* (L.f.)Pers.	3.57	-	3.13	-	4.26	-	.55	-	1.8	-	0.71	-	4.13	-	4.20	-	4.96	-
3.	*Euphorbia indica* Lam.	-	5.41	-	-	-	-	-	1.80	-	-	-	-	-	7.21	-	-	-	-
4.	*Dichanthium annulatum* (Forsk.) Stapf	-	5.41	9.38	-	2.13	-	-	1.50	4.31	-	0.95	-	-	6.91	13.6	-	3.07	-
5.	*Artemisia scoparia* Waldst. & Kit.	7.14	-	-	-	6.38	-	2.2	-	-	-	0.71	-	9.36	-	-	-	7.09	-
6.	*Cynodon dactylon* (L.) Pers.	3.57	21.6	12.5	8.0	-	17.3	1.39	29.7	14.5	4.96	-	8.33	4.96	51.3	27.0	12.9	-	25.7
7.	*Barleria cristata* L.	-	-	-	4.0	4.26	-	-	-	-	0.58	0.95	-	-	-	-	4.58	5.20	-
8.	*Malvastrum coromandelianum* (L.)Grackle.	-	5.41	-	-	-	-	-	2.40	-	-	-	-	-	7.81	-	-	-	-
9.	*Ipomoea carnea* Jacq.	-	2.70	6.25	4.0	-	8.7	-	0.90	1.62	0.87	-	2.50	-	3.60	7.87	11.2	-	11.2
10.	*Rhynchosia minima* (L.) DC.	-	2.70	-	-	2.13	-	-	1.20	-	-	0.47	-	-	3.90	-	-	2.60	-
11.	*Chamaesyce hirta* (L.) Millsp.	-	-	3.13	-	-	-	-	-	0.81	-	-	-	-	-	3.93	-	-	-
12.	*Alternanthera pun. gens* Kunth	-	-	6.90	-	-	-	-	-	3.77	-	-	-	-	-	6.90	-	-	-
13.	*Erigeron* sp.	-	-	-	-	-	17.3	-	-	-	-	-	5.83	-	-	-	-	-	23.2
14.	*Cyperus rotundus* L.	-	-	-	-	4.26	-	-	-	-	-	2.13	-	-	-	-	-	6.38	-
15.	*Solanum surattense* Burm. f.	-	-	-	-	-	4.35	-	-	-	-	-	0.83	-	-	-	-	-	5.18
16.	*Boerhavia procumbens* Roxb.	-	5.41	-	-	-	-	-	1.80	-	-	-	-	-	7.21	-	-	-	-
17.	*Atylosia mollis* Benth.	-	-	-	-	14.9	-	-	-	-	-	3.31	-	-	-	-	-	18.2	-
18.	*Lantana camara* L.	14.2	-	-	20.0	12.7	8.7	4.43	-	-	10.5	1.89	4.17	18.7	-	-	30.5	14.6	12.8
19.	*Senna occidentalis* (L.) Link	-	-	-	-	17.0	-	-	-	-	-	4.26	-	-	-	-	-	21.2	-
20.	*Desmostachya bipinnata* (L.) Stapf.	3.57	13.5	3.13	4.0	-	4.35	2.77	21.9	1.08	1.17	-	2.50	6.34	35.4	4.20	5.17	-	6.85
21.	*Heteropogon contortus* (L.) P.Beauv.	-	18.9	-	4.0	-	-	-	11.1	-	0.87	-	-	-	30.0-	-	4.87	-	-
22.	*Abutilon indicum* (L.) Sweet	-	-	6.25	8.0	-	-	-	-	2.96	3.21	-	-	-	-	9.21	11.2	-	-
23.	*Datura innoxia* Miller	7.14	-	-	-	-	-	1.39	-	-	-	-	-	8.53	-	-	-	-	-
24.	*Saccharum spontanum* L.	-	-	9.38	4.0	-	-	-	-	2.16	0.58	-	-	-	-	11.5	4.58	-	-
25.	*Cannabis sativa* L.	3.57	-	-	-	3.07	-	0.55	-	-	-	0.95	-	18.7	-	-	-	3.07	-
26.	*Adhatoda vasica* Nees	-	-	-	-	9.7	-	-	-	-	-	1.18	-	-	-	-	-	9.7	-
27.	*Trichodesma indicum* (L.) R.Br.	-	5.41	-	-	-	-	-	-	-	-	-	-	-	7.81	-	-	-	-
28.	*Sida cordata* Burm.f	7.14	-	-	-	-	-	1.94	-	-	-	-	-	9.08	-	-	-	-	-
29.	*Achyranthes aspera* L.	17.8	-	-	-	-	-	6.93	-	-	-	-	-	24.7	-	-	-	-	-
30.	*Euphorbia prostrata* Ait.	-	-	15.6	8.0	-	-	-	-	5.93	2.33	-	-	-	-	21.0	103	-	-

R.F = Relative frequency R.D = Relative density I.V.= Importance value

Parthenium hysterophorus being the most dominant and *Lantana camara* L., being the second most dominant weed species of sector G-9 with an importance values of 111 and 30.5 respectively (Table 1). The observations further revealed that most of the roadsides were vegetated with perennial grasses such as *Desmostachya bipinnata* (L.) Stapf, *Cynodon dactylon,Heteropogon contortus* and *Saccharum spontanum* L.

The analysis of the data collected from sector G-10 of Islamabad indicated that most of the sampled area in this sector was dominated with *Parthenium hysterophorus* and *Senna occidentalis. Senna occidentalis* and *P. hysterophorus* showed high values for relative frequency (17 & 21.2%). However, *P. hysterophorus* (111) exhibited a higher importance value than any of the weed species in this sector (Table 1). *Atylosia mollis* was the third most dominant species after *P. hysterophorus* and *Senna occidentalis*, with importance value of 18.2. The data for other herbaceous flora including *Lespediza juncea, Rhyncosia minima* and *Trichodesma indicum* (L.) R. Br., which are medicinal herbs, indicated that their population is under decline.

The analysis of the data collected from sector G-11 of Islamabad showed that the weed *P. hysterophorus* was associated with six other weed species. *Parthenium hysterophorus* had the highest importance value (114), relative density (75.8%) and frequency (39.1%). Being co-dominant with *P. hysterophorus*, *C. dactylon* showed second highest importance value (25.7), relative density (8.3%) and frequency (17.3%).

Discussion

Parthenium hysterophorus has become a major weed of various areas of the country in a relatively short time. This weed is not included in Wild flowers of Rawalpindi and Islamabad by Nasir *et al*., (1987), Flora of Punjab by Ahmad (1980), Flora of West Pakistan by Stewart (1972), Identification of Angiosperms by Ahmad (1964) and Lahore district flora by Kashyap (1936). Both water and air are apparently major vectors of its spread in arable parts of the country. According to Navie *et al*., (1996) most of the dispersal of seed is through vehicular and mechanized farming which leads to long distance dispersal in India and Australia.

The present study revealed that *P. hysterophorus* has become a major pest plant of the wastelands and metropolitan areas of Islamabad with the potential to spread all over the country. The phytosociological survey of Islamabad showed a high frequency of *P. hysterophorus* in general, however, the relative frequency of weed in different sectors of the city ranged from 13.5% to 39.1%. The area under *P.hysterophorus* infestation was approximately 29% of total area of wastelands of Islamabad that were sampled. McFadyen (1992), surveying Central Queensland, Australia, reported that over 10% of the area was infested by *P. hysterophorus*. A similar pattern of invasion was noticed by Oudhia (2001) in a phytosociological survey of weeds of the rainy season with special reference to *P. hysterophorus* in Raipur, India. He found that *P. hysterophorus, Senna tora* (L.) Roxb., and *Achyranthes aspera* L. dominated the vegetation

The high relative dominance and importance value of *P. hysterophorus* may be attributed to its aggressiveness and allelopathic effects on the neighboring plants (Adkins & Sowerby, 1996; Kohli, 1985). Navie *et al*., (1996) emphasized several other aspects of the ecology of this weed that appear to contribute to its aggressiveness, including the size and persistence of its soil seed bank, high viability of seed when buried, fast germination rate and the innate dormancy mechanism of its seed. Joshi (1991) recorded that *P. hysterophorus* is an extremely prolific seed producer, with up to 25000 seeds/plant, and that it had an enormous seed bank in abandoned fields of India.

Once dominant, parthenium weed continues to persist as a pure stand or weed monoculture until it is managed. It was noticed during the survey that *P. hysterophorus* prefers to invade areas that have been recently disturbed and where topsoil is removed. This in turn minimizes the competition from native species and enhances the chances of survival of the invading plants. It is further demonstrated that this weed has aggressively colonized the open lands, pasture lands and wastelands of the capital.

In a survey of sectors G-7 and G-11, it was found that *P. hysterophorus* and *Desmostachya bipinnata* had a high degree of sociability and these formed large stands under different habitats. Naithani (1987) observed that *Senna uniflora* (Mill) Irwin Barneby had good sociability with *P. hysterophorus*, and that this plant overgrew *P. hysterophorus* in India. In sectors G-9 and G-10, *Lantana camara* exhibited a high sociability with *P. hysterophorus*. The co-dominance of *M. coromandelianum* was clearly evident in these sectors.

In Islamabad, many other plants have already been labelled to be the causes of the pollen allergy and hay fever. *Broussonetia papyrifera* and some grasses are considered to be the main allergy causing agents in Islamabad. Heavy infestation of *P. hysterophorus*, which has also been proved to be an allergy causing plant, poses a serious threat to the inhabitants of the Islamabad. Siriramaro *et al.,* (1991) conducted aero-pollen sampling in Banglore (Southern India) over a six-year period and revealed that 40-60% of total pollen counts were from *P. hysterophorus*. Subsequent studies by Suresh *et al*., (1994) from northern India showed that a significant proportion of bronchial asthma patients were sensitive to the pollen of *P. hysterophorus.* The studies of McFadyen (1995) in Australia are in line with the findings of these Indian authors.

Islamabad and the adjoining areas have been recognized as a rich repository of natural herbs, which are used in indigenous systems of medicines like Hikmat, Tib and Homeopathy. These valuable plants are adapted to a wide range of agro-climatic conditions and soil textures. Some of them also prefer to grow on degraded soils and wastelands, however these areas are being quickly invaded by *P. hysterophorus* .In view of the attributes that increase the competitive ability of *P. hysterophorus*, the existence of economic herbs in wastelands is under a serious threat. *Artemisia scoparia* and *Tribulus terrestris* were once common medicinal plant species growing in the wastelands of these sectors. The current data on these herbs exhibited a tremendous decline in their population. Mahadevappa *et al.,* (2001) reported that *P. hysterphorus* had become a curse for the natural herbs of Chhattisgarh plains of India. Similarly, Chippendale & Panetta (1994) revealed that this weed had the potential to disrupt the natural ecosystems of Australia. *Cannabis sativa,* another exotic invasive species, was once the most dominant weed species amongst the herbaceous flora of Islamabad. It is now being replaced by *P. hysterophorus*, which is a very versatile species that exhibits characters such as strong allelopathy and a rapid growth rate.

The wastelands are a potential source of naturally growing herbs, but if the increasing population of parthenium weed is not contained, it is most likely to replace these medicinal plants. Secondly, the inhabitants of Islamabad are already sensitive to the pollen of many other plants and parthenium weed, being notorious for its pollen allergy, poses a serious threat to health of the capital.

Acknowledgements

The author is thankful to Dr. Tahira Zafar Mahmood, PSO Weed Science Department, National Agriculture Research Centre (NARC), Islamabad for providing technical help and Mr. Mushtaq Ahmad, Plant Taxonomist, University of Arid Agiculture Rawalpindi in helping the identification of plants of the site surveyed.

References

Adkins, S.W. and M.S. Sowerby. 1996. Allelopathic potential of *Parthenium hysterophorus* L., in Australia. *Pl. Prot. Quar*., 1: 20-23.

Ahmad, S. 1964. *Identification of angiosperms*. Lahore Art Press. Lahore, Pakistan.

Ahmad, S. 1980. *Flora of the Punjab Biological Society of Pakistan*. Monograph 9-10 published by Biological Society, Government College Lahore, Pakistan.

Chippendale, J.F. and F.D. Panetta. 1994. The cost of *Parthenium* weed to the Queensland cattle industry *Pl. Prot. Quar*., 9: 73-76.

Joshi, D. 2001. Alien invasive species: A global threat to biodiversity. *The Katmandu Post* Sunday Dec. 23, 2001.

Joshi, S. 1991. Interference effects of *Cassia uniflora* Mill on *P. hysterophorus* L. *Plant and Soil*, 132: 113-118.

Kanchan, S. and Jayachandra. 1980. Pollen allelopathy a new phenomenon. *New Phytologist*, 84: 739-746.

Kanchan, S.D. 1975. Growth inhibitors from *Parthenium hysterophorus* Linn. *Current Science*, 44: 358-359.

Kayshap, S.R. 1936 *Lahore district Flora*. University of the Punjab, Lahore.

Kohli, R.K., A. Kumari and D.B. Saxena. 1985. Auto and teletoxicity of *Parthenium hysterophorus* L. *Acta University Agriculturae Brnol* (Czechoslovakia). 33: 253-263.

Labrada, R. 1990. El an manego de malezas en areasde hortalizas V frijal en cuba, X congreso ALAM, La Habana, abril 1-14, Vol II: 1-16.

Lonkar, A., J.C. Mitchell and C.B. Calnan. 1974. Contact dermatitis from *Parthenium hyusterophorus. Transactions of the St John's Dermatological Society*, 60: 43-53.

Mahadevapa, M., T.K. Das and A. Kumar. 2001. Seminar. "*The Herbal State*" organized by Sirsthi herbal Academy and Research Institute, held at Raipur (India) during 13-14 December 2001.

Mahadevappa, M. 1997. Ecology, distribution, menace and management of parthenium. In: *Proceedings of the 1st International Conference on Parthenium Management*, (Eds.): M. Mahadevappa and V.C. Patil. 6-8 October 1997, University of Agricultural Sciences, Dahrwad, India, 1-12.

McFadyen, R.E. 1992 Biological control against parthenium weed in Australia. *Crop Protection* 11: 400-407.

McFadyen, R.E. 1995 *Parthenium* weed and human health in Queensland. *Australian Family Physician*, 24: 1455-1459.

Naithani, H.B. 1987 *Parthenium hysterophorus* a pernicious weed in Arunachal Pradesh and Nagaland. *Indian Forester*, 113: 709-710.

Nasir, E., Y.J. Nasir and R. Akhtar. 1987. Wild flowers of Rawalpindi-Isalamabad districts, National Herbarium, PARC, Garden Graphics Ltd. Karachi Pakistan.

Navie, S.C., R.E Mc Fadyen, F.D. Panetta and S.W. Adkins. 1996. The biology of Australian weeds 27, *Parthenium hysterophorous* L. *Plant Protect. Quart*,. 11: 76-88.

Oudhia, P. 2000. Medicinal Herbs and Insects of Chhattisgarh India. *Insect Environment*, 6: 138.

Oudhia, P. 2001. Phytosociological survey of rainy season weeds of wastelands with special reference to *Pathenium hysterophorus* in Raipur district. http:// www.IPRNG.org

Rajan, L., 1973. Growth inhibitor(s) from *Parthenium hysterophorus. Current Science*, 42: 729-730.

Raju, R.A. and M. Reddy Nageswara. 1998. Phytosociological studies of rainy season weeds with special reference to *Imperata cyliderica* (L.) Raeuhl in Gadavari Delta. *Indian J. weed Sci*., 30: 182-188.

Shabbir, A. 2002. *Parthenium hysterophorus L; An exotic weed threatening the biodiversity and agricultural lands of Islamabad and adjoining districts.* M. Phil thesis Department of Botany University of the Punjab, Lahore, Pakistan.

Singh, N.P. 1983. Potential biological control of *Parthenium hysterophorus* L. *Current Science*, 52: 644.

Sriramarao, P., S. Nagpal, B.S. Rao, O. Prakash and P.V. Rao. 1991. Immediate hypersensitivity to *Parthenium hysterophorus*. II. Clinical studies on the prevalence of *Parthenium rhinitis*. *Clinical Experimental Allergy*, 21: 55-62.

Stewart, R.R., 1972. *Flora of West Pakistan*. Fakhri Printing Press. Karachi, Pakistan.

Suresh, P.V., D. Gupta, D. Behera and S.K. Jindal. 1994. Bronchial provation with *Parthenium* pollen extract in bronchial asthema. *Indian Journal of Chest Diseases and Allied Sciences*, 36: 104.

Tudor, G.D., A.L. Ford, T.R. Armstrong and E.K. Bromage. 1982. Taints in meat from sheep grazing *Parthenium hysterophorus*. *Aus. J. of Exp. Agri. and Ani. Husbandry*, 22: 43-46.

(Received for publication 14 February 2006)