ASRCT Bibliographical Series No. 4

WATER HYACINTH ABSTRACTS

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THAI NATIONAL DOCUMENTATION CENTRE

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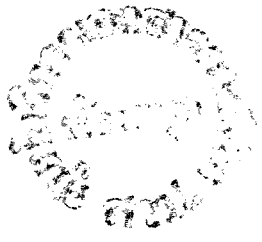
INTERNATIONAL FEDERATION FOR DOCUMENTATION
COMMISSION FOR ASIA AND OCEANIA

APPLIED SCIENTIFIC RESEARCH CORPORATION OF THAILAND
Bangkok, 1974



FOREWORD

In 1972 the "Water Hyacinth Abstracts" was published as a draft in a limited number being a part of contribution to the research and development programme on "Biological Control of Noxious Aquatic Weeds in the Mekhong Basin" operated by the Agricultural Products Research Institute, Applied Scientific Research Corporation of Thailand. Since then concurrent requests have been received from institutions both inland and abroad, thus proper printing will be appropriated for a wider circulation.

As informations pertaining to the subject are currently gathered and already accumulated; it is, therefore, worthwhile to incorporate additional abstracts up to 1971 in this edition.

The publication is kindly sponsored by the Commission for Asia and Oceania of the International Federation for Documentation (FID/CAO), to which obligation is herewith acknowledged.

Mrs. Chalermvarn Choosup
Director
Thai National Documentation Centre

WATER HYACINTH ABSTRACTS

1. ABDALLA, A.A. and ABDEL HAFEEZ, A.T.
1969. Some aspects of utilization of water hyacinth (Eichhornia crassipes). PANS, 15(2):204-7. (Bibl. 2; Fac. Agric. Univ. Khartoum, Sudan)

Chemical analysis of E. crassipes showed a very high P content, average N and K and low Ca contents compared with some crop plants; burning and using the ash as a fertilizer is recommended. Mulching with E. crassipes (20% moisture content) at 60 kg/plot (3 X 3.7 m) for 3 weeks reduced the mean growth rate of leaves of Cyperus rotundus from 5.2 to 3 mm/day and increased the moisture content of the surface soil by 33%. -Weed Abstr. 19(1),1970.

2. ABOU-EL-FADL, M. and others
1970. Utilization of water hyacinth as an organic manure with special reference to water-borne helminths. J. Microbiol. U.A.R., 3(1):27-34.

Examination of fresh water hyacinths (Eichhornia crassipes Schlecht.) and snails in the immediate vicinity of the plants has not revealed the presence of infectious stages of water-borne helminths. The water hyacinth, however, must be composted before it is utilized as organic manure. -Biol. Abstr. 52(18),1971.

3. AGRICULTURAL RESEARCH, WASHINGTON
1967. Herbicide cuts water loss. Agric. Res., Wash., 16(4):9.

Cessation of evapotranspiration following the control of thick mats of water hyacinth (Eichhornia crassipes) with 2,4-D was demonstrated in growth pool trials. -Weed Abstr. 17(3),1968.

4. AHMAD, NAZIR
1968. Review of research work done by the Directorate of Fisheries, West Pakistan. Agric. Pakist., 19(3):557-72. (Directorate Fish., Lahore, W. Pakistan)

Eichhornia crassipes at Balloki fish farm was controlled by a foliar applied 25% aqueous solution of 2,4-D.

Grass carp (Ctenopharyngodon idella). Nearly half a million fry were flown from Canton in 1964 for stocking in the Haleji Lake in 1965 to control weed overgrowth. The fish voraciously consumed Hydrilla sp. Potamogeton sp. and Vallisneria sp.

Weeds of Kalri Lake. Silt deposits are responsible for the profuse growth of Typha sp., Scirpus sp., Phragmites sp. and Paspalum sp. There is a luxuriant growth of Hydrilla sp., Vallisneria sp., Potamogeton sp. and Ceratophyllum sp. down to depths of 2-16 ft., Potamogeton pectinatus descends to 20 ft.

Weed of Mancher Lake. Mancher L. covers up to 100 mile^2 and is situated in the Sehwan Taluga of Dadu district. The shallowness of water and the alluvial bed promote the overgrowth of aquatic vegetation (which spoils the scenic beauty of the lake by giving it a marshy appearance), harbour mosquitoes, restrict fishing operations, and promote the proliferation of weed fishes and the silting up of the lake. The main weeds are as for Kalri Lake with the addition of Cyperus sp. and Nymphaea sp.

Study on the food and feeding habits of major carps. Gut contents of 16- to 52-cm. long Catla catla consisted mainly of micro-crustacea and filamentous and colonial algae with some higher plants; diatoms were the main diet in December and January, colonial algae in March and April, Chlorophyceae and Cyanophyceae in May-June, and remnants of aquatic vegetation in October. C. catla is a surface and mid-water feeder. The gut contents of 9- to 58-cm. long Labeo rohita consisted mainly of colonial and filamentous algae and also vegetable and algal detritus; it is a column feeder. The gut contents of 12.5- to 34-cm. long Cirrhina mrigala consisted of decayed vegetable and algal matter with a large quantity of mud; Chlorophyceae and Cyanophyceae were also represented. -Weed Abstr. 19(4),1970.

5. AMCHEM PRODUCTS Inc.

1963. Aquatic weed control with fenac. Tech. Serv. Data Sheet Amchem Products Inc., H-91, 15 p. tabs. 4, bibl. 28.

This report is based on research carried out in the US and Canada on the use of fenac as a soil-applied pre-em. treatment to the bottoms of irrigation ditches, lakes and ponds and as water-surface treatments. Fenac is available as a 10% formulation on 8-15 mesh "A" LVM attaclay (Fenac Granular) and as a liquid Na salt formulation containing 1.5 lb a.e./gal.

Initial studies have shown fenac to be active against Alternanthera philoxeroides and Eichhornia crassipes at high rates. In current trials it has reduced the amount of phenoxy compounds, such as 2,4-D and fenoprop, needed to control A. philoxeroides, in addition to effectively delaying resprouting. When used with amitrole-T to control E. crassipes, it increased the rate of knock-down and subsequent sinking.

In trials in 1961 and '62, three formulations of fenac applied in the autumn or the spring were evaluated for the control of Potamogeton pectinatus in irrigation ditches. The soil was partially frozen at the time of the autumn treatment, and alternately thawed and froze for some time after application. Rainfall was 3.74 in. from 9 November, at the time of autumn treatment, to 12 May when the ditch was flooded. From 20 April, the date of the spring applications, until the ditch was flooded 22 days later, 1.81 in. of rain fell. Assessments were made on 10 July after the ditch had been drained. The granular Na and liquid amide and Na formulations at 20# applied in the autumn gave respectively 93, 95 and 95% control of P. pectinatus. At 10# , these formulations gave respectively 95, 80 and 78% control, indicating that there was no advantage gained by using the granular formulation at the higher rate. Both the granular and liquid Na formulations applied in spring gave approximately 70% control of P. pectinatus.

In other trials in 1960-62, fenac was evaluated together with 2,4-D, atrazine and simazine as pre- and post-em. soil sterilant applications to control submersed aquatic weeds in lakes and canals. Soil types varied from decomposed granite/silt mixtures to clays, clay/loams and in one lake a clay/humus ooze. Incorporation of the herbicide in the surface soil through adequate leaching was found to be essential for canal treatments prior to admitting flowing water. Fenac at 5 and 20# gave 80 and 95% control, respectively, of P. nodosus in a canal where 8 to 10 in. of rain fell prior to flooding, but was ineffective against weeds in two other canal trials where 4 in. of rain fell before submergence.

In the reservoir and lake tests, applications were made directly to the soil. The plots received amounts ranging from a trace up to 4 in. of rainfall before being gradually covered by impounded water. Under these conditions, weed control was effective in all trials, regardless of the amount of rainfall prior to submerging the plots. Both the sodium salt and amide formulations of fenac at 10 and 20# were superior to 2,4-D at 20 and 40# against P. nodosus and P. diversifolius. Granular formulations of fenac amide at 10 and 20# and 2,4-D 30 and 60# applied through the water before plant growth began to give complete control of P. nodosus, P. pectinatus and Najas guadalupensis. Fenac applied during the winter dormant season showed promise as a soil sterilant for season-long control of many submerged weed species, as well as Eleocharis acicularis and Typha sp.

In a series of trials in which fenac was applied to lake bottoms, fenac at 15# applied in January controlled P. pectinatus, Elodea sp., Heteranthera dubia and Utricularia sp. for a season and showed some residual activity during the second year. At another location, fenac at 7.5# applied in October controlled Myriophyllum brasiliense, Heteranthera dubia and Potamogeton spp. M. brasiliense regenerated. Fenac at 20# applied after draw-down before weed emergence gave 85-100% control of Sagittaria spp., Polygonum spp., Alisma spp., Eleocharis spp. and Ludwigia spp.

In ditches, fenac at 2# +a 2,4-D+2,4,5-T mixture at 8# provided adequate control of small brush species, herbaceous broad-leaf weeds and submersed aquatic weeds in shallow pools.

Rates of 12 and 15# applied to the surface of small pools and embayments infested with P. pectinatus have resulted in 90% and complete kill, respectively, within 5 to 7 weeks. Granular fenac at 3 ppm. applied in July to parts of a 3-ac pond eliminated P. pusillus within 2 weeks, while complete knock-down of P. nodosus was not obtained until early September.

Studies have been carried out to determine the TL_m (median tolerance limit / LD_{50} / values in ppm.) of several fish species. In general, a TL_m of 20 or above has been established for a wide range of fish species, indicating a probable 10-fold safety factor over the normal recommended rates of application. After 24 hours, a TL_m of 22.5 and 20 for liquid and granular fenac on bluegill sunfish / Lepomis macrochirus / was obtained. After 96 hours a TL_m of 125 and 30 for liquid and granular formulations on walleye pike (Stizosedion vitrium), 300 and 400 on sucker (Catostomus commersoni) and 130 for the liquid formulation on muskellunge (Esox masquinongy) was obtained. An application of granular fenac did not appear to have any effect on plankton and benthic organisms.

In a water residue study, fenac at 20# was applied in the spring of 1962 to a 2500-ft length of irrigation canal. When water was turned into the canal 5 weeks after treatment, the first wave of water that flowed over the treated area contained approximately 8.5 ppm. fenac. The relatively high concentration declined rapidly and after 30 min. amounted to 0.86 ppm. The reduction was evidently due to dilution within the ponded section of the canal, since little water flowed beyond the treated area during this time. Twenty minutes later, water began to flow from the treated length of canal and contained 0.496 ppm. of fenac. After 2 hours the concentration dropped to 6.5 ppb. and after 8 hours amounted to only 2 ppb.

It was concluded that inadequate rainfall after the onset of the trial failed to leach the chemical sufficiently to prevent high concentrations being carried away with the initial flow of water, but that, even under these conditions, the water should be safe for use on cropped land within several hours after being introduced into the canal. -Weed Abstr. 13(5),1964.

6. ANON.

1925. The Water-Hyacinth and its utilization. Agric. J. India 20:395-96.

Recent experiments in cotton at the Institute of Plant Industry in India have demonstrated that water hyacinth, converted to finely divided organic matter, can be profitably used as a manure. In the Chinese manner, successive loads of fresh water weed were mixed with earth, cow-dung and wood ashes and spread in layers on a rectangle, 18 X 12 ft. The heap was covered with earth to retard drying. Active fermentation commenced and the heap was converted to a damp moist mass. After one month the heap was turned to promote aeration. Manure was ready for use after 2 months.

It is suggested that the weed be allowed to dry partially in the sun before the heap is made to prevent excessive water oozing from the heap with loss of valuable compounds. Composting should take place after the monsoon, between October and March. Such compost could be used for cold weather crops, jute, rice, vegetables and fruit. -A.H.

7. ANON.

1962. Agricultural Research. (Agrisearch notes). Agric. Res., Wash., 10(8):15.

A single application of amitrole + NH_4SCN at 0.5-2# gave more effective control of water hyacinth (Eichhornia crassipes) than 2,4-D at 2-6#.

A mature, 7-in. spike of Typha latifolia may produce up to 222,000 seeds. The rhizomes and shoots from one seed can spread over an area of 10 ft. in diam. in 6 months. -Weed Abstr. 11(3),1962.

8. ANON.

1964. Water hyacinth is one of the world's worst weeds. N.Z.J. Agric., 108(3):232, figs.2.

The recognition of water hyacinth and the potential dangers of its rapid spread are described briefly. -Weed Abstr. 14(2),1965.

9. ANON.

1965. A symposium on Man-Made Lakes (tropical and temperate), organized by the Institute of Biology, was held in London on 30 Sept.-1 Oct., 1965.

Man-made lakes are now coming to occupy great areas of former land, especially in Africa, e.g. the Kariba Dam on the Zambesi, 1700 sq. miles; the Volta Dam in Ghana, 3200 sq. miles; Lake Nasser on the Nile, 1800 sq. miles. The great size of such lakes demands that full use be made of them, not only for hydroelectric power, transport, etc., but also for the irrigation of crops. Reference is made to the serious invasion of man-made lakes by aquatic weeds, such as Salvinia auriculata, Pistia stratiotes and Eichhornia crassipes. -Field Crop Abstr. 19(2), 1966.

10. ANON.

1966. Mulching with water hyacinth (Eichhornia crassipes). Two and a Bud 13(1):31.

A brief note on the possible use of water hyacinth as a mulch in young tea in N.E. India. The plants are of great manurial value as well; in a dry state they contain about 70% organic matter, 1.5% N, 0.6% P_2O_5, and 5.5% K_2O. -Trop. Abstr. 21(10),1966.

11. ANON.

1966. A study on the usage of water hyacinth as animal feed in Thailand. Bangkok. A Special Meeting of the ASA Joint Working Party, 27-29 July, 1966, 2 p.

To date, chopped water hyacinth leaves have been used as roughage in swine feed: Other livestock will not eat it. Experiments were made to investigate its use as an animal feed.

Attempts to convert water hyacinth to silage were inconclusive due to high shrinkage in the silo due to high water content. It was shown that, after drying in the sun, leaves of Eichhornia azurea and E. crassipes had moisture contents of 90.34 and 86.01% respectively, the corresponding figures for roots being 95.35 and 94.61%. Weight due to this high water contents makes it uneconomical to transport the plant for long distances. Values for dry weight nutritive components such as fat, protein and ash, before, at and after flowering, are given. Mixing powdered water hyacinth at 5% to 20% into feed of white mice (for which this food is not usual) resulted in reduced growth rate and increased number of deaths.

The present practice of feeding water hyacinth to swine as roughage and a vitamin supplement should be continued. It should not comprise more than 5% dry weight of the mixture: young vegetative plants should be used, preference being given to leaves over roots. - A.H.

12. ANON.

1966. Water Hyacinth as bedding material for the cultivation of Volvaria mushroom. (Philippines). Kuala Lumpur, Malaysia, 3rd Meeting of the ASA Joint Working Party, 27-30 April, 1966, 2 p.

The working paper covers 3 aspects of water hyacinth utilization in the Philippines.

Dried water hyacinth can be used as a bedding material for Volvaria mushroom. Plants thoroughly dried in the sun are arranged in 10" thick layers, layers being alternately aligned. Each layer is watered, well trampled and planted with mushroom spawn. During the hot months, yields of mushroom are high. The first harvest is 10-14 days after planting; a bed 4 X ½ X 1 meter may yield 12-15 kg. fresh mushrooms. Mushrooms are larger than those grown on rice straw.

Comparing properties of different kinds of silage, water hyacinth has the lowest temperature and Para grass the lowest moisture and highest dry matter. A mixture of Para grass and water hyacinth had the best calcium-phosphorus ratio and gave the best yield of silage. Red Sindhi cows daily consumed 11.13 kg. of the pure hyacinth silage.

Tests relating to possible use of water hyacinth for pulp and paper making gave values for components of the rootless plants as: lignin 7.1%, ash 11.2% pentosan 18.9%, silica 0.8%, holocellulose 65.5%. The pulp yield, 31.1%, was lower than those from other agricultural wastes. The wrapping paper from water hyacinth had poor strength. -A.H.

13. ANON.

1966. Aquatic weeds and navigation. Biokemia, (14):9.

In a trial on navigable waterways at Pemex City, Tabasco, Mexico, 95% of a dense infestation of Eichhornia crassipes and Pontederia cordata decomposed and sank 8 weeks after applying Esteron 10-10S at 7.5 l./hā in 85 l. Water +7.5 l. diesel oil from a helicopter. -Weed Abstr. 17(1),1968.

14. ANON.

1967. Water Hyacinth Research (Philippines). Bangkok, Meeting of the Committee on Technical Cooperation and Research, 23-25 Jan. 1967, 2 p.

The working paper reports yields of volvariella mushroom grown on water hyacinth bedding material and considers whether such bedding material is suitable for cultivation of Agaricus mushroom.

Volvariella mushrooms can be harvested from a dried water hyacinth bed 9-12 days after planting: a bed 4 X 1 X ½ meter may yield 8-12 kg. fresh mushrooms. The bed remains productive for 2-3 weeks. Mushrooms grown on water hyacinth are larger than those grown on rice straw.

It is expected that chemical fertilizers will be needed to raise the nutritional value of dry water hyacinth for proper growth of Agaricus mushroom. -A.H.

15. ANON.

1968. New dam in Nigeria. Nature, 220(5171):957-8.

Includes the information that weeds may never constitute a problem in the Kainji dam. Salvinia nymphellula, which is common in the area, appears to be native to West Africa and has not been reported to form mats. S. auriculata and Eichhornia crassipes have not been reported in the area while Pistia stratiotes, usually common, is not a problem. On the other hand fish production may be adversely affected by phytoplankton blooms. Within 8 weeks of the formation of the lake surface scums of Anabaena sp. were widespread in the middle zone. -Weed Abstr. 18(2),1969.

16. ANON.

1969. Possibilities of biological control of aquatic weeds in India. Water Resource J. September 1969, 40-50. (ST/ECAFE/Ser. C/82)

In India aquatic weeds cause a considerable nuisance by polluting drinking water, providing breeding sites for mosquitoes and impeding fish culture, irrigation and navigation. Most of the major weeds are not native to India: Eichhornia spread from Ceylon, Ludwigia from America, probably via Africa, and Alternanthera philoxeroides from South America. Weed control measures are few: due to lack of funds, mechanical control is used only when absolutely necessary and chemical control is negligible.

Since extra funds will not be available in the near future, biological control measures must be investigated. The following are biocontrol agents which have proved successful in experiments or in the field elsewhere: aquatic mammals, Trichechus inunguis, Myocastou coypus; fish Ctenopharyngodon idella; Snails, Marisa cornuarietis, Pomacea canaliculata; insects and mites, Agasicles sp. Recently a government survey was made of natural enemies of aquatic weeds in India in the hope that it might give pointers to suitable foreign biocontrol agents.

Trials in Trinidad suggest the following insects should be tested in the field in India against the 2 most serious weeds, Eichhornia crassipes and Salvinia auriculata. Species which attack E. crassipes are; from South America, Acigona ignitalis, Epipagis albiguttalis, Cornops longicorne, Neochetina spp. Orthogalumna terebrantis, from North America, Arzama densa. Species which attack Salvinia sp. are: Cyrtobagous singularis, Paulinia acuminata and Samea multiplicalis. -A.H.

17. ANON.

1971. Economic Damage caused by Aquatic Weeds (Preliminary Survey). U.S., Office of Science and Technology, Agency for International Development, Washington D.C., December 1971, 13 p. (TA/OST/71-5)

The report attempts to estimate the economic significance of aquatic weeds in developing countries, considering only these weeds in bodies of water. The most important aquatic weeds in such countries, including submerged, emergent and free floating forms, are listed, together with their distribution: Eichhornia crassipes (Mekong, Malaysia, Indonesia, Ceylon, Upper Nile etc.) Azolla spp. (Mekong, Lake Kariba, Congo, Nile), Pistia stratiotes (Mekong, Malaysia, India, E. Africa, Central America etc.), Hydrilla (Mekong, N.E. Thailand, Indonesia, Vietnam, Laos etc.), Alternanthera philoxeroides (N.E. Thailand, Indonesia, Laos etc.) and Cyperaceae (Mekong, Malaysia etc.). Major harmful effects of these weeds are: water loss by transpiration, reduced oxygen content of water, provision of breeding sites for disease vectors, increased silting, and interference with drainage, water traffic and power plants.

Economic losses due to these weeds have been estimated for some developed countries: in the Mississippi delta, water hyacinth caused annual losses of 35 million dollars due to impeded agricultural transport. Annual cost for eradication in Florida is 3.6 million dollars. Similar costs in developing countries are likely to affect their economies.

The Zambian economy depends on short haul water transportation which is impeded by weeds for 8 months of the year causing losses of 3%. Clearance schemes cost 1 million dollars annually. In Thailand, where 30% of the labour force is concerned with fishing and water transport, the lower Mekong river basin is infested with water hyacinth, water lettuce and water fern. Control has been estimated as likely to cost several million dollars initially with a further annual expenditure of 400,000 dollars. In Guyana, E. crassipes interferes with irrigation and transport of sugar cane and rice causing annual losses of 250,000 dollars: 100,000 dollars are required annually for minimal control measures. Such a large sum will have a serious impact on the shaky economy. In these 3 developing countries water weeds have been implicated in recent increased spread of schistosomiasis. -A.H.

18. ARNOTT, H.J.

1966. Studies of calcification in plants (Yucca schidigera, Lemna minor and Eichhornia crassipes. In: Proceedings of the Third European Symposium of calcified tissues, 11-16 April, 1965, Davos, Switz., Springer-Verlag, Inc., New York. Calcified Tissues Proc. Europe Symp. 3:152-157, Illus.

The formation of calcium oxalate crystals in the plants investigated is a biologically controlled process, intimately associated with cellular differentiation. Crystal development occurs by the formation of loaded chambers associated with membranes and tubules; subsequently crystals are formed within these chambers. The possibility that the chamber acts like a boule is suggested. -Biol. Abstr. 48,1967.

19. AUDIA, W.V. and PRESTON, W.H.
1965. The effects of several algicides on aquatic plants. Proc. 19th NE Weed Control Conf., 451-5. (Pestic. Reg. Div., Agric. Res. Serv., US Dept. Agric. Beltsville, Maryland)

Several algicides were applied to outdoor ponds containing aquatic plants during the summer of 1964. Calcium hypochlorite, dichlone and potassium chlorate were not phytotoxic to Juncus effusus, Sagittaria sinensis, Ludwigia palustris, Marsilea quadrifolia, Lemna minor, Azolla caroliniana, Salvinia rotundifolia, Ceratopteris thalictroides, Eichhornia crassipes and Pistia stratiotes. An alkyl benzyldimethylammonium chloride and a mixture of 4 quaternary ammonium compounds were moderately phytotoxic to E. crassipes and killed another plants except J. effusus and S. sinensis. Phenylmercuric acetate and copper sulphate damaged most of the floating plants but not those established in soil.

In the greenhouse, 15 algicides were tested for phytotoxicity to A. caroliniana: within 18 days, 6 quaternary ammonium compounds copper sulphate, phenylmercuric acetate and a mixture of monuron, simazine, atrazine and dichlone caused moderate to severe growth inhibition. Copper nitrilochelate caused a slight growth reduction. Dichlone, calcium hypochlorite, potassium chlorate, potassium dichloroisocyanurate and a mixture of PCP Na technical with 2-mercaptobenzothiazole caused no apparent injury or growth inhibition. -Weed Abstr. 16(4),1967.

20. AVAULT, J.W.
1965. Biological weed control with herbivorous fish. (Abstract) Proc. 18th Sth. Weed Control Conf., 590-1. (Alabama Agric. Exp. Stn., Auburn)

In trials in plastic-lined pools, Congo tilapia (Tilapia melanopleura) stocked at rates between 1500 and 1000/ac controlled the following within 3 months: Pithophora sp., Spirogyra sp., Eleocharis acicularis, Elodea densa, Hydrochloa sp., Utricularia biflora and Rhizoclonium sp., whereas Najus guadalupensis, Potamogeton diversifolius, Chara sp. and Spirodela polyrhiza were controlled by increasing the stocking rate to 2055 and 2440.

Grass carp (Ctenopharyngodon idellus), stocked in pools at 685/ac, eliminated all the above-mentioned species within 3 weeks. On resumption of feeding 2 to 3 weeks later, Alternanthera philoxeroides, Myriophyllum brasiliense, M. spicatum and Eichhornia crassipes were eliminated within 2 weeks. Chara sp., P. diversifolius and E. acicularis were controlled within 1 month of stocking at rates down to 20-40/ac. In ponds, Israeli carp (Cyprinus carpio) 6 to 9 in. long at 25-50/ac reduced or eliminated Pithophora sp., Rhizoclonium sp. and E. acicularis within 2 to 3 years.

Channel catfish (Ictalurus punctatus) reduced or eliminated Pithophora sp. when stocked in ponds at 100/ac, but not when stocked at 200/ac. Stocked in pools at 685/ac, these fish consumed higher plants in the absence of alternative food. Nile tilapia (Tilapia nilotica) controlled Pithophora sp. when stocked in pools at 2055/ac and in ponds at 1000-2000/ac. In pools, some reduction of E. acicularis, N. guadalupensis and P. diversifolius was obtained. Java tilapia (T. mossambica) at 1000-2000/ac and goldfish (Carassius auratus) at 685/ac controlled Pithophora sp. in pools. Both these species and Tampa tilapia (T. heudeloti) fed on, but failed to control higher plants. -Weed Abstr. 15(3),1966.

21. AVERITT, W.K.

1967. The persistence of 2,4-D in water. In: University of South-western Louisiana and Corps of Engineers, Department of the Army (USA). An annual report of the control of alligator weed and other aquatic plants, 325-47.

In December 1965, with water temperature around 70°F, 2,4-D amine at 4# was sprayed onto water hyacinth (Eichhornia crassipes) along the banks of Bayou Teche, St. Martinville, Louisiana. Two sets of water samples analysed showed a high concn. after 1 h.(153 and 29 pp thousand million) and a reduced concn. after 24 h. (37 and 30) which increased again 1 week after application (727 and 1020), perhaps because of absorbed chemical released through submerged portions of the plants. There was a gradual decrease of concn. in samples taken at 2 weeks and thereafter. Owing to the low temperature the action of 2,4-D on the plants was slow. The same general trend in 2,4-D concns. was observed in tanks when water hyacinths were sprayed in May 1966, under warmer conditions.

In the same month 2,4-D methylamine 4# was sprayed in two lagoons in City Park, New Orleans by injecting the herbicide into the propeller wash from a motor boat. In both cases the concn. decreased very rapidly between the 3rd and 4th day after application.

In July six tanks with growing water hyacinth were paired. Three tanks were sprayed with 2,4-D methylamine, Esteron 99 (2,4-D propylene glycol butyl ether esters) or Kuron (fenoprop propylene glycol butyl ether esters, each at 4# and three with the same herbicides + blackstrap molasses 1 gal/ac. There were higher herbicide concns. on the 2nd or 3rd day than on the 1st day, and concns. then gradually decreased until 3 or 4 weeks after application when they increased again followed by a decrease to the end of the test period (122 days) when only Kuron was detected. The water in tanks receiving molasses showed a delayed but similar concn. fluctuation compared to that in tanks treated with herbicide alone. In September, on a pond, 2,4-D methylamine at 4# was applied to exposed portions of alligator weed (Alternanthera philoxeroides) on about 1/100 ac. Water analyses showed trends similar to those of the lagoons but owing to rainfall 8 h. after spraying the results may be misleading. There was apparently no diffusion of herbicide to points 100 ft. and 150 ft. from the treated area up to 53 days after spraying. -Weed Abstr. 17(5),1968.

22. BAKER, H.G.

1965. Characteristics and modes of origin of weeds. The genetics of colonizing species: Proc. 1st Internat. Union Biol. Sci., Asilomar, California; ed. by H.G. Baker and G.L. Stebbins. Academic Press Inc. N.Y. 147-72. (Bibl. 35; Univ. California, Berkeley)

A discussion of the factors that enable a species to become a weed. The 'ideal' weed 1. Has no special environmental requirements for germination 2. Has discontinuous germination and great longevity of seed 3. Shows rapid seedling growth 4. Spends only a short time in the vegetative condition before flowering 5. Maintains seed production as long as growing conditions permit 6. Is self-compatible, but not necessarily self-pollinated or apomictic 7. If cross-pollinated, can be pollinated by a non-specialized flower visitor or by wind 8. Produces numerous seeds in favourable environment 9. Can produce some seed in a very wide range of environments 10. Has special adaptations for short- and long-distance dispersal 11. If a perennial, has vigorous vegetative reporduction 12. If a perennial, is brittle at the lower nodes of rhizomes or rootstocks 13. If a perennial, can regenerate from severed portions of the rootstock 14. Can compete by special means, for example rosette formation, high competition or exocrine production.

Species mentioned include Ageratum conyzoides, Eupatorium microstemon, E. adenophorum, Oxalis corymbosa, O. pes-caprae, Eichhornia crassipes, Polypodium dispersum, Hypericum perforatum, Senecio squalidus, Epilobium pedunculare, Acaena anserinifolia, Tetragonolopus maritimus and Raphanus sativus. -Weed Abstr. 17(4),1968.

23. BARTON, L.V. and HOTCHKISS, J.E.

1951. Germination of Seeds of Eichhornia Crassipes Solms. Boyce Thompson Inst. 16(5):215-20.

A combination of high temperature and light is needed for complete germination of dormant seeds of Eichhornia crassipes. However, periods of eight hours a day at a temperature as low as 5°C. did not impair germination in the greenhouse and daily alternating temperatures of 5°- 30°, 5°- 35°, and 5°- 40°C. permitted some germination in dark incubators. Constant temperatures of 30° and 40°C failed to bring about germination in the dark. After 17 months of storage in water at 20° or 30°C , the seeds became less dormant as evidenced by their germination over a wider range of temperatures, but alternating low and high temperatures of greenhouse conditions were still best. These seeds germinated at fluctuating air or water temperatures as low as 22°C in the sunlight in the greenhouse. Thus sunlight favored the germination of dormant seeds or of non-dormant seeds held at unfavorable low temperatures.

Samples which had germinated in the greenhouse after storage in water for various lengths of time at temperatures ranging from approximately 4°C - 40°C showed 20° and 30°C better than lower or higher temperatures for keeping the seeds viable as long as 17 months. It was also demonstrated that the speed of germination of all lots was hastened by a storage period of a month or longer, and the percentage of germination of the less mature lot C was greatly increased by such treatment. -Author

24. BAUER, S.

1966. Helicopter against water hyacinth in the Sudan. Agric. Aviat., 8(4):116-18.

A 2,4-D emulsion containing 4.5 kg a.i./ha in 40 l. spray applied from a helicopter provided 98% control of water hyacinth (Eichhornia crassipes) on tracts of the White Nile in the Malakal area, and appeared more effective than trial applications of invert emulsions produced by Bi-Fluid spray equipment. Optimum times of year for spraying in this area were between May and August on the stretch between Jebel Aulia and Malakal, and between December and April on the stretch between Malakal and Juba. Herbicidal activity appeared to be unaffected by relatively high shade temperatures (up to 43°C). -Weed Abstr. 16(3),1967.

25. BEASLEY, P.G. and LAWRENCE, J.M.

1966. The influence of rooted aquatic plants on the dissolved oxygen content of water. Abstr. Meet. Weed Soc. Am., p. 90. (Auburn Univ. Agric. Exp. Stn. Alabama)

The effect of dense growths of submersed vegetation on the dissolved oxygen (d.o.) content of water was studied in plastic pools and natural waters during 1965. In plastic pools 24 in. deep in which 50% of the surface was covered by Eichhornia crassipes and 80 to 90% of the volume occupied by submersed Najas guadalupensis the d.o. ranged from 0.3 to 1 ppm at the surface and 0.1 to 0.4 ppm at the bottom. Most of the fish stocked in these pools died probably as a result of oxygen depletion. In pools in which < 20% of the surface and volume was occupied by weeds, however, the d.o. ranged from 4.6 to 8.4 ppm at the surface and from 4.4 to 8.7 at the bottom.

In the Sealey Pond area of Lake Seminole which was choked with Potamogeton crispus and Nitella spp. the d.o. content was 4.5, 3.4 and 0.5 ppm at depths of 0, 5, and 10 ft. respectively in August when the surface water temperature was 33°C. In October when the temperature had fallen to about 23°C the d.o. content at these was 5.5, 5.4 and 3 ppm. In an open water area at the same surface water temperature the d.o. content was 8, 8.7, 5.7 and 4 ppm at depths of 0, 10, 20 and 30 ft. in August and 7.9, 6.1 5.8 and 5.8 ppm in October. The results confirm that the d.o. content of water in weed infested areas is appreciably lower than that in open water regions of the same impoundment. No data on fish populations in Lake Seminole are available to indicate the extent to which utilization of these areas by fish is reduced. - Weed Abstr. 16(6),1967.

26. BENNETT, F.D.

1966. Investigations on the Insect Attacking the Aquatic Ferns, Salvinia spp. in Trinidad and Northern South America. Proc. Southern Weed Conf. 19,1966, 497-504.

The floating aquatic fern, Salvinia auriculata, indigenous to South and Central America has become a serious pest in many areas because of its rapid vegetative growth. As well as impeding water flow it provides food for Biomphalaria boissyi, the intermediate snail vector of Bilharizia. The possibilities of using coypu, Marisa cornuarietis, etc. for biological control have been considered. This investigation of insect pests on Salvinia occurring in northern South America was authorized by the Rhodesian government with a view to possible control of the weed in the Kariba lake.

30 Species of insect were collected and reared: 3 promising species, Cyrtobagous singularis, Samea multiplicalis and Paulinia acuminata are discussed fully. C. singularis was found in northern Brazil and British Guiana: both adults and larvae injure Salvinia to which they are host specific. P. acuminata is widely distributed throughout subtropical South America and Trinidad. Nymphs (5 stages) and adults feed on leaves: where food is limited destruction is rapid. Paulinia can feed on other aquatic plants but terrestrial economic plants are rejected: water grown rice was nibbled slightly. Samea multiplicalis was widely spread in the area studied. Severe damage was inflicted by the larva which could also feed on Pistia stratiotes but not on other plants.

Methods used to screen Salvinia insects are given. The principles of biological control of aquatic weeds are discussed. -A.H.

27. BENNETT, F.D.

1967. Notes on the possibility of biological control of the water hyacinth, Eichhornia crassipes. PANS (Sect. C. Weed Control) 13(4):304-9.

Eichhornia crassipes has become a highly noxious aquatic weed because, unlike the 4 other known species of the genus, it can maintain itself without contact with the soil. Investigations on its natural enemies have so far only been conducted in northern and eastern Brazil, Uruguay, and India; research in its centre of origin may reveal many more diseases and pests associated with it. So far the most promising species for biological control are the stem borer Chilo ignitalis, an arctiid moth (Palustra sp.) and a galumnid mite from S. America, and the aquatic grasshopper Gesonula punctifrons from India. The snail Marisa cornuarietis in Puerto Rico damages E. crassipes but also attacks rice seedlings. Work on the biological control of another aquatic weed, Salvinia auriculata, is also under way. 16 refs. -Trop. Abstr. 23,1968.

28. BENNETT, F.D.

1968. Insects and mites as potential controlling agents of water hyacinth. Proc. 9th Brit. Weed Control Conf. 1968, 4 p.

Surveys were made in the countries where Eichhornia crassipes originated, Guiana, Surinam, Brazil, Trinidad, Jamaica, British Honduras and Florida to determine whether insects occur which are capable of restricting the growth rate of the plant. The more promising insects occurring in Trinidad are being tested for host specificity.

Potential biological control agents found in South America and Trinidad were Acigona ignitalis, Epipagis albiguttalis, Leptogalumna sp., Neochetina bruchi, Cornops longicorne and Thrypticies sp. In Jamaica, only Leptogalumna sp. appeared of interest: in British Honduras Cornops sp. was the only interesting find. In Florida, Arzama densa successfully attacks water hyacinth. -A.H.

29. BENNETT, F.D.

1968. Investigations on insects attacking water hyacinth in Florida, British Honduras and Jamaica, 1968. Commonwealth Agricultural Bureaux, Farnham Royal, Bucks, England, 9 p. (cyclo.). (Bibl. 6; Commonwealth Institute of Biological Control, West Indian Station, Curepe, Trinidad)

The insects observed on Eichhornia crassipes are noted and the damage they cause is explained. The occurrence of Arzama densa (which may reduce the production of viable seed) on E. crassipes in Florida is of interest. It has apparently transferred successfully from an allied host, Pontederia cordata, and several of its natural enemies have followed it. It may be suitable for release in new areas after host specificity tests. -Weed Abstr. 18(3),1969.

30. BENNETT, F.D.

1970. Insects attacking water hyacinth in the West Indies, British Honduras and the USA. Hyacinth Control J., 8(2):10-13. (Bibl. 5; Commonw. Inst. Biol. Control, Curepe, Trinidad)

Insects and mites found on survey trips are described briefly, and further notes are given on those considered to have a narrow host range. The noctuid Arzama densa, found on Pontederia cordata and Eichhornia crassipes and present at a high rate in the warmer months at some localities in Florida, may be useful in regions where its natural predators are absent, if it proves sufficiently host specific. The pyralid Samea multiplicalis has been observed on several water plants including Salvinia auriculata and E. crassipes. The weevil Sphenophorus pontederiae was found on E. crassipes in Florida, and the weevil Neochetina sp. was associated with it in S. Trinidad. The leaf-mining mite Orthogalumna terebrantis was found outside S. America for the first time, on E. crassipes in Jamaica and Florida, and appeared to be confined to this host. Progress on host specificity studies in Trinidad on the grasshopper Cornops longicorne and the pyralids Acigona ignitalis and Epipagis albiguttalis is recorded. All 3 appeared to prefer E. crassipes as host plant and A. ignitalis larvae were found to need it to develop normally. Further tests are to be carried out with these species. -Weed Abstr. 20(4),1971.

31. BENNETT, F.D.

1970. Recent investigations on the biological control of some tropical and subtropical weeds. Proc. 10th Br. Weed Control Conf., 660-8. (Bibl. 30; Commonw. Inst. Biol. Control, Gordon St., Curepe, Trinidad)

A résumé of investigations on the biological control of weeds undertaken by the West Indian Station of the Commonwealth Institute of Biological Control is given. Since its inception in 1946 this station has been involved with research on the biological control of eleven species of weeds. Outstanding control of two, Cordia curassavica in Maruitius and Opuntia spp. in Nevis has been achieved by the introduction of phytophagous insects, and encouraging results have been obtained against Tribulus cistoides in St. Kitts. The complex of insects associated with several weeds including the important aquatic weeds Eichhornia crassipes and Salvinia auriculata as well as the terrestrial species Eupatorium odoratum are currently under investigation. -Weed Abstr. 20(5),1971.

32. BENNETT, F.D. and ZWOLFER, H.

1968. Report on a survey of the insects and mites associated with Water Hyacinth, Eichhornia crassipes in northern South America undertaken in February-March, 1968, 29 p.

In northern South America, the centre of origin of Eichhornia, a survey was made of promising pest species for introduction as biological control agents for water hyacinth in other areas. Similar investigations have previously been made in India and Uruguay. Distribution of the five species of Eichhornia and related genera is given: E. crassipes, E. paniculata, E. paradoxa, E. azurea and E. diversifolia occur in subtropical and tropical America, E. diversifolia also occurs in tropical Africa.

The survey itinerary included Guiana, Surinam and Brazil. An attempt was made to examine damage and collect pests on E. crassipes and other species on Pontederiaceae over as wide a range of habitats as possible: artificial and natural lakes and ponds, canals and drainage ditches, swampy pasture lands and rivers.

An exhaustive investigation of pest species collected has not been completed and details of only the most promising species are given. These are: Neochetina bruchi, Acigona ignitalis, Epipagis albiguttalis, Cornops longicorne (life history studies and host specificity tests are being made on these spp.). Leptogalumna sp. and Thrypticus sp. (Palustra spp. and Arzama densa have been noted in previous studies). -A.H.

33. BERG, A.

1959. Analysis of the conditions unsuitable for the development of water hyacinth (E. crassipes) in certain rivers of the Congo basin. Bull. Agric. Congo Belge 50(2):365-93. (bibl. 6, illus., Flemish summary)

The exploration of the River Congo and its tributaries between Mokweti and Coquilhatville showed that conditions in most of these rivers are unsuitable for the development of water hyacinth. From the study of this phenomenon it was concluded that water hyacinth does not grow in water with a pH value constantly lower than 4.2. -Field Crop Abstr. 13,1960.

34. BERG, A.

1961. The ecological role of the waters of the Congo basin in the growth of water hyacinth. Mem. Classe Sci. Nat. Med. Acad. Roy. Sci. d'Outre Mer. 12(3):120 p. (Fr,e,du) figs. 12, tabs. 17, bibl. 32.

The first part of this report on an investigation carried out from 1957-9 describes in detail the waters of the Congo basin rivers and classifies them according to 3 types: (1) humic acid waters with a pH of 3.5-5.2 (these are limited to the central Congo Basin); (2) humic waters partially neutralized by mineral bases, with pH of 5-7 (these are basin waters originating from the plateau); and (3) humic waters completely neutralized, with pH of 6+ and average pH of 7.6 (these are in the plateau or at the start of their course through the basin).

A survey of the distribution of E. crassipes showed that humic acid waters with a pH below 4.2 are toxic to the plant and are therefore not infested. A pH of 4.2-4.3 appears to be inhibitory, 4.3-4.5 doubtful and 4.5-5.2 non-inhibitory. Light appears to accentuate the toxic effect. The present distribution of E. crassipes in the Congo basin can therefore be explained by (1) propagation by upstream navigation, (2) propagation by downstream current, (3) inhibition by waters of pH 4.3 or lower, and (4) artificial destruction by man. The 2-year compaign with 2,4-D showed that complete eradication in the Congo basin by this means was impossible.

Details are given of laboratory experiments in which the plant grew satisfactorily in natural waters of pH 7 or 5 and in water adjusted artificially to pH 7 or 5 with NaOH, declined rapidly at a natural pH of 4 and grew more slowly but was not completely inhibited at artificial pH 4.

It was concluded that the toxic effect on the plant of humic waters of low pH must be attributed essentially to a mineral deficiency, due partly to the abundance of hydrogen ions in a poor mineral environment and also to absorption of the cations on the humic colloids. -Weed Abstr. 12(4),1963.

35. BHANJA, A. and SIRCAR, S.M.
1966. Gibberellins from the root of water hyacinth. Sci. Cult., 32(7):371-72.

The roots of water hyacinth have been observed to have growth promoting effects on several crops including rice, wheat, maize, pea, gram and jute. Accordingly a sample of root material was extracted with 80% ethanol and filtered and the aqueous residue remaining after evaporation of the filtrate, acidified and extracted with ethyl acetate. Subsequently extracts were partitioned against phosphate alkali buffer, centrifuged, acidified and re-extracted with ethyl acetate. The purified extracts were then chromatographed. A substance having an Rf value corresponding to that of GA_3 was shown to promote the growth of mustard and lettuce hypocotyls in bioassay tests. Following the alkaline hydrolysis of the water fraction, after removal of all the ether soluble free growth substances, the presence of gibberellin in some bound form was also indicated. As water hyacinth covers extensive areas it might be possible to use it for large scale extraction. - Weed Abstr. 17(5),1968.

36. BHATIA, H.L.
1970. Grass carps can control aquatic weeds. Indian Fmg., 20(2):36-7. (Fish. Res. Lab., Bhopal, India)

Five grass carps (Ctenopharyngodon idella) averaging 1-1.25 kg in weight were introduced to each of three 1500-ft^2 ponds and fed daily with quantities of individual weed species; unconsumed weeds were netted out every 24 h and weighed. Grass carps daily consumed > 100-150% of their body weight of Najas minor (174%), Hydrilla verticillata, Ceratophyllum demersum, Vallisneria spiralis, Podostemon ceratophyllum and Potamogeton crispus and consumed 60-77% of their body weight of Lemna minor, and 18-40% of their body weight of Myriophyllum spathulatum and Eichhornia crassipes. A mixture of 45 kg of 7 weed species was fed to five 6.5 kg fish and the mixture was netted out daily and the weight of individual weeds determined. The order of preference shown by the fish was N. minor > H. verticillata > C. demersum > L. minor > M. spathulatum > V. spiralis > E. crassipes; E. crassipes was consumed only as a last resort. The 5 fishes took a total time of 144 h to consume all the 45 kg of weeds. -Weed Abstr. 20(4),1971.

37. BHUTAROBOL, CHAINARONG
1951. Water hyacinth (Eichhornia crassipes) control experiments with 2,4-D at Angthong. Kasikorn 24:449-452.

To prevent damage to their rice crop, rice farmers of a district in Angthong Province had to remove the growth of this weed by pushing it out into the river to float it away. This cost as much as Baht 60 per rai.

2,4-D sprayed onto the weeds at the rate of 500 grams to 400 litres of water (0.1%) killed them within 25 days. The cost of this chemical treatment including labour and other charges was only one - third that of hand collecting and floating the weeds away. -Author

38. BILL, S.M.

1969. The water weed problem in Australia. Hyacinth Contr. J. 8(1):1-6. (State River Wat. Supply Commn., Victoria, Australia)

Aquatic weeds pose a serious problem in Australia in areas under irrigation. In Victoria, where $300,000 was spent on weed control in irrigation and drainage systems during 1966-67, the main herbicides used are aminotriazole, acrolein, dalapon, TCA and diuron. About 40% of the total annual expenditure for chemical control of aquatic weeds in Victoria is accounted for by the treatment of Paspalum distichum in drainage ditches with aminotriazole, while acrolein is the most useful chemical in water supply channels. Weed problems and control measures in New South Wales are similar to those in Victoria. Typha angustifolia, which is the most common aquatic weed in W. Australia, is generally controlled with 2,4-D ester at 8# , though aminotriazole and dalapon are also used. Eichhornia crassipes is not generally a serious problem in Australia with the possible exception of some Queensland rivers.

Elodea canadensis has been controlled on Albert Park Lake, Melbourne with acrolein injected below the water surface at a concn. of 12 ppmv followed six weeks later by 10 ppmv and subsequent annual treatments of 5 ppmv; the same compound has been moderately successful at 5 ppmv against weeds (mostly Potamogeton crispus) on Lake Burley Griffin, Canberra, but heavy fish kill has occurred in some parts of the treated area. In dams in Victoria Lemna minor, Azolla filiculoides and Potamogeton ochreatus are common, while P. pectinatus and Najas tenuifolia occur in dams in southern New South Wales. Herbicides are not widely used in farm dams and small reservoirs, except against such emersed species as T. angustifolia, rushes (Juncus spp., Scirpus spp. and Eleocharis spp.) and sedges (Cyperus spp. and Carex spp.). -Weed Abstr. 20,1971.

39. BLACKBURN, R.D.

1963. Evaluating herbicides against aquatic weeds. Weeds, 11(1): 21-4, tabs. 4, bibl. 10 (U.S. Dept. Agric., Fort Lauderdale, Florida)

Techniques are described for evaluating the effectiveness of herbicides against aquatic weeds in the laboratory.

Diquat, paraquat, endothal di-N, N-dimethyl-cocoamine and acrolein gave > 85% control of Elodea densa, Najas guadalupensis and Ceratophyllum demersum when these were grown for 4 weeks in the laboratory under water containing the herbicides in concentrations of 1 ppm., but only endothal and acrolein adequately controlled submerged weeds in contact with the herbicides for a limited period of 24 hr. Diquat at 1# in 100 gal water, sprayed over the foliage of floating weeds (Pistia stratiotes, Eichhornia crassipes and Salvinia rotundifolia) gave 78-85% control, but some regrowth of E. crassipes

occurred within 8 weeks 2,4-D tertiary fatty acid amine was more effective against floating weeds than was equivalent rates of 2,4-D ester. Only fenoprop butoxyethanol ester delayed sprouting of the underwater nodes of floating mats of Alternanthera philoxeroides for 8 weeks, in addition to giving top-kill. -Weed Abstr. 12(6),1963.

40. BLACKBURN, R.D. and ANDRES, L.A.
1968. The snail, the mermaid and the flea beetle. Agric. Yb., U.S. Dept. Agric., 229-34. (USDA Aquatic Weed Investigations, Crops Res. Div., Agric. Res. Serv., Fort Lauderdale, Florida)

Experiments in which marisa snails (Marisa cornuarietis), manatees (Trichechus sp.) and flea beetles (Agasicles sp.) have been used to control aquatic weeds are discussed. Work at Fort Lauderadale since 1965 has shown that all submersed weed species are controlled by marisa snails which will also eat floating leaves such as those of Salvinia sp., and the roots of Eichhornia crassipes and Pistia stratiotes but not aerial portions of the plant. In an enclosed body of water snail populations fluctuate with weed populations. Further work is being undertaken to investigate the production of snails for large stocking programmes (see also Weed Abstr. 15:940). Flea beetles are being used successfully for the control of alligator weed (Alternanthera philoxeroides) in Florida but have failed to damage this plant on the National Wildlife and Game Refuge at Savannah, where the use of thrips is being investigated. In a 3-year study at Florida Atlantic University 5 manatees ate the submerged weeds in a half-mile section of canal in 3 weeks but were unable to survive in water temperatures below 65°F. Test sites were free from vegetation for 6-8 months after the manatees were removed. -Weed Abstr. 19(3),1970.

41. BLACKBURN, R.D. and WELDON, L.W.
1962. Evaluation of herbicides for control of aquatic weeds. Annu. Rep. Florida Agric. Exp. Stas. 257 p. (U.S. Dept. Agric., Fort Lauderdale, Florida)

Alligator weed (Alternanthera philoxeroides). Fenoprop esters, either in herbicidal oil or as weighted emulsions, were generally the most effective treatment for the control of A. philoxeroides. The propylene glycol butyl ether ester of fenoprop was more effective than the butyl ether ester formulation. Dichlorprop, the most promising of the dichlorophenoxy compounds tested, and the n-butyl and 2-chloroethyl esters of 2-chloro-4-fluorophenoxy acetic acid, were more effective than 2,4-D. Adding a wetter increased the herbicidal effect of fenoprop and 2,4-D. In still-water pools, fenac sodium and fenac acetamide were effective against both floating and rooted-immersed clumps, the latter at 10# giving 99% control 9 months after treatment in 1 trial.

Water hyacinth (Eichhornia crassipes). In green-house trials, diquat at 2# + 0.1% wetter gave excellent control. The tertiary fatty acid amine salt of 2,4-D was approximately 50% more active than the diethanolamine salt. In field trials, amitrole-T at 1# and 2,4-D at 2 or 4# gave > 90% control, initial sinking occurring 12 and 9 weeks respectively, after treatment.

Other species. An aerial application of diquat at 0.5, 1 and 1.5# gave good control of water lettuce (Pistia stratiotes) but not of E. crassipes. Diquat applied in a canal at 2.5 ppm. in June provided complete control of southern naiad (Najas guadalupensis) and coontail (Ceratophyllum sp.) for 6 months. -Weed Abstr. 13(2),1964.

42. BLACKBURN, R.D. and WELDON, L.W.
1963. Results of 3 years of testing diquat as an aquatic herbicide in Florida. Proc. 16th Southern Weed Conf., 1963, 365 p. (Crops Res. Div., U.S. Dept. Agric., Fort Lauderdale, Florida)

Diquat at concentrations down to 0.25 ppmw. controlled submerged weeds in small ponds. In canals in S. Florida where flow could be stopped for 24-36 hr, 1 ppmw. controlled Najas guadalupensis and Ceratophyllum demersum; higher concentrations were required for complete control of dense stands of Elodea densa. Floating species, such as Eichhornia crassipes, Pistia stratiotes and Salvinia rotundifolia, were controlled with rates of 1-1.5# , but retreatment was required for complete control. Foliar sprays of 10# gave initial top-kill of Alternanthera philoxeroides, but submerged stems regrew within 2-3 weeks. In laboratory trials, Spirodela polyrhiza was killed by 0.05 ppmw., but in field trials, 0.25 ppmw. was required to control several other duckweed species. Concentrations of 0.5 ppmw. appeared to have little effect on natural fauna and plankton in small ponds. Concentrations up to 2.5 ppmw. persisted in pond water for up to 11 days, but these were not toxic to fish. -Weed Abstr. 12(6),1963.

43. BLACKBURN, R.D. and WELDON, L.W.
1964. Chemical and physiological studies on aquatic weeds. Rep. Fla Agric. Exp. Stas., 301 p. (U.S. Dept. Agric. Fort Lauderdale, Florida)

On the environmental factors influencing submerged weeds in canals in S. Florida, light penetration, P and N compounds, sulphates, tannic acid and turbidity appeared to have the greatest effect on weed growth. In some localities where plants were damaged by insects, chemical control of alligator weed (Alternanthera philoxeroides) was found to be impracticable.

In trials with amitrole-T, the best top-kill of aquatic weeds was obtained with 1.5# , and 1# was considered to be the minimum rate required for satisfactory results. The addition of fenac at 1, 2 and 4 oz/ac to amitrole-T resulted in more rapid top-kill. In glasshouse trials, fenac appeared to influence translocation of amitrole-T in water hyacinth (Eichhornia crassipes). When used as a chemical marker, fenac at 1 or 2 oz should be added to amitrole-T at 1-1.5# . -Weed Abstr. 14(4),1965.

44. BLACKBURN, R.D. and WELDON, L.W.
1964. Evaluation of herbicides for control of aquatic weeds. Rep. Fla. Agric. Exp. Stas., 297-8. (U.S. Dept. Agric., Fort Lauderdale, Florida)

In trials on the control of alligator weed (Alternanthera philoxeroides) the activity of fenoprop at 8# was enhanced by the addition of several herbicides though the mixtures proved less economic than did fenoprop alone. Two applications of picloram at 5# were also effective, while paraquat formulated on perlite granules showed some promise against floating infestations. The addition of diglycolic acid to 2,4-D, fenoprop and picloram resulted in more rapid top-kill than was obtained with these chemicals applied alone.

A food-grade emulsifier, ACL-210, increased the activity of amitrole-T against water hyacinth (Eichhornia crassipes). -Weed Abstr. 14(4),1965.

45. BLACKBURN, R.D. and WELDON, L.W.
1965. Field applications of aquatic herbicides; and ecological studies. Rep. Fla. Agric. Exp. Stn., 318-19. (Plantation Field Lab., Fort Lauderdale, Florida)

Fenoprop gave the best control of alligator weed (Alternanthera philoxeroides). Applications should begin in May-July and should be repeated 2-5 times. A floating granular formulation of paraquat at 4 # (2 treatments) was also quite effective.

Helicopter applications of an invert emulsion of 2,4-D either as an oil-emulsifiable amine or an ester gave just as good control of water hyacinth (Eichhornia crassipes) as the conventional 2,4-D amine in water.

The most important factor influencing the sumbersed aquatic plants in four south Florida canals was light as related to depth. The seasonal growth cycle was reversed from the usual summer peaks by flow reduction during the winter which allowed gradual clearing of the water and greater light penetration. The high tannic acid concn. in more northernly canals had a very pronounced effect on light penetration.

Diquat and paraquat controlled southern naiad (Najas sp.) and coontail (Ceratophyllum demersum) in small ponds and canals when applied at rates of 1-2 gal per surface acre. Rates of 1 ppm. did not give complete control of elodea. Paraquat as a foliar spray and a floating granule at 2 and 6 # controlled southern watergrass (Paspalum dilatatum) in small ponds. -Weed Abstr. 15(5/6),1966.

46. BLACKBURN, R.D. and WELDON, L.W.
1966. Evaluation of herbicides for control of aquatic weeds. Rep. Fla. Agric. Exp. Stn., 303 p. (Univ. Florida, Gainesville)

Of 60 new herbicides tested few had any effect on alligator weed (Alternanthera philoxeroides). Diglycolic acid combined with 2 and 4 lb/gal formulations of 2,4-D propylene glycol butyl ether ester was less effective than standard treatment with fenoprop. A paraffin emulsion added to dichlobenil increased its foliar activity. Of 40 new herbicides evaluated on water hyacinth (Eichhornia crassipes) in the glasshouse ametryne and G.S. 14260 (4-ethylamino-2-methyl-thio-6-t-butylamino-1,3,5-triazine) proved the most effective. In laboratory experiments with 3 submersed species control was effected with 4-dimethylaminothiocyanobenzene. -Weed Abstr. 16(6),1967.

47. BLACKBURN, R.D. and WELDON, L.W.
1966. Field applications of aquatic herbicides and ecological studies. Rep. Fla. Agric. Exp. Stn., 306-7. (Univ. Florida, Gainesville)

Lasting abatement of carbohydrate levels in under-water stems of alligator weed (Alternanthera philoxeroides) has been achieved using fenoprop at 8 # applied initially in March, May or July and repeated 1-3 times. The period of greatest response appears to be May or June. Paraquat at 4-6# in floating granule formulation was fairly effective against surface growth. Fenoprop at 8 lb in 16 gal spray/ac applied as an invert emulsion using the bifluid spray system has also shown promise in the control of alligator weed. Ametryne at 2-3# is effective as a possible alternative for 2,4-D in the control of water hyacinth (Eichhornia crassipes). TD 191 (endothal

mono-N, N'-dimethylcocoamine) at 1 ppmw. in non-flowing canals and 2 ppmw. in tidal waters was very effective in controlling elodea (Elodea sp.) and southern naiad (Najas guadalupensis). Diquat combined with copper sulphate was more effective on elodea than either applied alone. Paraquat at 1-2# was very effective in control of southern watergrass (Hydrochloa caroliniensis). Marisa snails stocked at 4000 per ac in ponds over a 3-yr period freed these from submerged weeds except for spatterdock (Nuphar advena). Amitrole-T (aminotriazole + ammonium thiocyanate) was translocated from treated water hyacinth to connected untreated plants in sufficient quantities to give control. -Weed Abstr. 16(6),1967.

48. BLACKBURN, R.D. and WELDON, L.W.

1967. Evaluation of herbicides for control of aquatic weeds. Rep. Fla. Agric. Exp. Stns., 309-10. (Univ. Florida, Gainsville)

See also Weed Abstr. 16:2255. Of 107 new herbicides tested in the greenhouse during the year most had little activity on alligator weed (Alternanthera philoxeroides). 2,4-D tertiary amine was more effective than the standard formulation. Of 43 new herbicides evaluted on water hyacinth (Eichhornia crassipes) in the greenhouse, NIA-11092 (1,1-dimethyl-3-(3-(N-t-butylcarbamoyloxy) phenyl) urea) and OCS-21794 (?) were the most promising. -Weed Abstr. 19(1),1970.

49. BLAKEY, H.L.

1966. Outlook for weed control activities. Hyacinth Contr. J., 5:18-20.

Following the termination in 1967 of a 5-year pilot project for the control of water hyacinth (Eichhornia crassipes) and alligator weed (Alternanthera philoxeroides) in eight S.E. coastal States, Congress has authorized the U.S. Army Engineers to implement an aquatic weed control programme for the continuation of work on the control of E. crassipes in the S. Atlantic and Gulf, Coast States and the study of problems involving Eurasian watermilfoil (Myriophyllum spicatum) marine algae and other estuarine infestations in the middle Atlantic States. -Weed Abstr. 16(4),1967.

50. BLANCHARD, J.H.

1965. Results of various aquatic weed control measures tested in Leon County, Florida. Hyacinth Contr. J., 4:3-4, bibl. 3. (Florida Game & Fresh-water Fish Commn., Fisheries Div., Panama City)

Nine 0.25 ac plots approximately 6 ft. deep were established in Lake Jackson on the south and west sides, and herbicides applied from an airboat in the early morning at wind velocities of < 5 miles per h. Aquathol Plus (endothal+fenoprop), diquat and paraquat were either injected at concn. of 7, 7 and 5 ppm. respectively or sprayed on the surface of the water at 2 quarts/plot. Endothal was injected only at 5 ppm. concn. and rock salt was broadcast at 200 and 600#. None of the materials tested gave sufficient control of maidencane (Panicum sp.) to warrant further use on a large scale. It was suggested that the 0.25 ac. plots allowed excessive lateral movement and hence dilution of the materials especially where salt was used, and that future sample plots should be on small lakes. All treatments gave some control of lotus (Nelumbo lutes), waterlilies (Nymphaea spp.) and

watershield (Brasenia schreberi) but only diquat controlled bladderwort (Utricularia spp.) and fanwort (Cabomba caroliniana)

At Lake Miccosukee, attempts to control maidencane by shading from water hyacinth (Eichhornia crassipes) were unsuccessful as the transplanted hyacinths failed to thrive or reproduce. -Weed Abstr. 15(5/6),1966.

51. BOCK, J.H.

1966. An ecological study of Eichhornia crassipes with special emphasis on its reproductive biology. Ph. D. Thesis Univ. California, Berkeley, 186 p.

Diss. Abstr. 28:61-B. -Weed Abstr. 17(3),1968.

52. BOCK, J.H.

1969. Productivity of the water hyacinth (Eichhornia crassipes). Ecology, 50(3):460-4. (Bibl. 9; Dept. Bot., Univ. California, Berkeley)

The results of field and growth chamber studies showed that the growth and reproduction rates of E. crassipes plants collected from Old River, San Joaquin County, California were comparable to those of water hyacinths growing in the tropics. Their rapid reproduction and high productivity in the summer months enable the populations to be maintained from year to year in northern California despite a high death rate in water. -Weed Abstr. 20(2),1971.

53. BOYD, C.E.

1969. The nutritive value of three species of water weeds. Econ. Bot., 23(2):123-27. (Bibl. 9; Agric. Exp. Stn., Auburn Univ., Alabama)

Further to the work described in Weed Abstr. 19: 445 samples from 15 stands of Eichhornia crassipes, 11 stands of Pistia stratiotes and 10 stands of Hydrilla sp. were collected from a number of different habitats in southern and central Florida and subjected to analyses for total available carbohydrate (TAC), crude protein, ash, cellulose, calorific content and moisture. Results on a dry wt. basis showed that mean crude protein levels for the 3 species were as high as for many quality forages, but on a fresh wt. basis levels were below 2.0% indicating that the plant material would have to be dehydrated prior to use as a foodstuff. Mean cellulose levels for E. crassipes and P. stratiotes were lower than for Hydrilla sp. and did not exceed those of some forage crops. Mean levels of TAC content were generally higher than those of forage species. Values for amino acids were similar to those for forage species of similar crude protein content. It is suggested that feeding trials may be initiated for all 3 species in areas where harvesting appears economically feasible. -Weed Abstr. 19(2),1970.

54. BOYD, C.E. and BLACKBURN, R.D.

1970. Seasonal changes in the proximate composition of some common aquatic weeds. Hyacinth Contr. J., 8(2):42-4. (Bibl. 9; Crops Res. Div., USDA, Fort Lauderdale, Florida 33314)

Data in respect of crude protein (on a fresh and dry weight basis), percent. d.m., ether extract and cellulose content are given for alligater weed (Alternanthera philoxeroides), eelgrass (Vallisneria americana), Florida elodea (Hydrilla verticillata), spatterdock (Nuphar advena), southern naiad (Najas guadalupensis), water hyacinth (Eichhornia crassipes) and water lettuce (Pistia stratiotes).

Estimations were made at monthly intervals from April to August. In A. philoxeroides and N. advena crude protein levels on a d.m. basis declined during the season: in the other species they rose. Calculations of seasonal changes in d.m., standing crop and harvestable crude protein for A. philoxeroides and Justicia americana are used to infer the best time to harvest for fodder value. All species were much higher in ash content than forage species, but on a wet wt. basis values would probably be similar to those of most forage crops, though problems might arise if the crops were to be dried. On a basis of data obtained for J. americana, it would seem desirable to adjust harvesting methods to obtain plant parts of the highest nutritive value. -Weed Abstr. 20,1971.

55. BRADDOCK, W.B.

1966. Weed control problems in the East Volusia Mosquito Control. Hyacinth Contr. J., 5:31. (E. Volusia Mosquito Control Distr., New Smyrna Beach,Florida)

Herbicidal treatments used in the E. Volusia Mosquito Control District for the maintenance of draining ditches are outlined. Dalapon Na in emulsified fuel oil is effective against grasses, including Typha latifolia, Myriophyllum brasiliense is suppressed for at least 1 year by 2,4-D granular, while a solution of 2,4-D (rate not stated) + No. 2 fuel oil at 10 gal + emulsifier at 2 quarts in 150 gal spray controls Limnobium spongia, Sagittaria sp. and Pontederia sp. A number of submersed species including algae encroaching on a site, previously cleared of Eichhornia crassipes by spraying with 2,4-D, were controlled by one application of copper sulphate followed by diquat. -Weed Abstr. 16(4),1967.

56. BROWN, W.H.

1951. Eichhornia crassipes-Botany. Useful Plant of the Philippines. Vol. I, 1951, 363-64.

The water hyacinth was originally introduced into the Philippines as an ornamental, grown in water in comparatively small containers. It has, however, become widely spread throughout the Philippines and grows in abundance. It often grows in streams and along the edges of lakes in such quantities as to become a nuisance to navigation. Sometimes it enters rice paddies near lakes in such quantities as to interfere with the growing of rice.

In the Philippines it is used very extensively in the building of fish traps. The plants are confined within comparatively narrow limits and the shade they afford causes fish to collect under them. The fish are then caught by nets.

The bases of the leaves, particularly under certain conditions, form conspicuous rounded bladders. These are eaten by ducks, pigs, and other animals and are used for this purpose.

Owing to their thick fibers, the petioles are made into shoe soles in some parts of the world.

According to Burkill this plant has a fairly high potash content and is therefore good manure.

Eichhornia crassipes is an aquatic plant with a rosette of leaves. It reproduces by means of runners which grow from the parent plant and from new plants. The flowers occur in spikes and are very handsome.

Eichhornia crassipes is a native of tropical America but is now abundant in the Tropics throughout the world.

57. BUREAU OF SUGAR EXPERIMENT STATIONS, QUEENSLAND, AUSTRALIA.

1966. Weed Control. Rep. Bur. Sug. Exp. Stns. Qd. (n.d.), 26-30.

Mimosa invisa. Young plants were controlled by 2,3,6-TBA 4.8% (all percentages given, or assumed to be given in terms of a.i., not a.e.) + MCPA 15% at 1, 1.5 and 2 gal/ac ± 0.5% wetter, but not by picloram 50% + 2,4-D 20% at 1, 1.5 and 2 pints/ac ± 0.25 and 0.5% wetter; mature plants, on the other hand, were completely controlled by picloram + 2,4-D at 2 gal/ac and a picloram + 2,4,5-T mixture at 1, 1.5 and 2 gal/ac, whereas 2,3,6-TBA + MCPA lacked activity. In general, aerial and ground applications of picloram + 2,4-D have proved less effective than the standard treatment of 2,4-D + 2,4,5-T and are not at present an economical proposition for the commercial control of M. invisa.

Brachiaria mutica (= Panicum purpurascens). In trials in the Innisfail area, bromacil alone at 16# and in mixtures at 12# + disodium methyl arsonate 7.5# remained sufficiently active to maintain complete suppression of B. mutica twelve months after treatment, but failed to prevent regrowth of Ageratum houstonianum.

Panicum maximum. In trials in standing cane in the Ingham area, mist applications of diuron 80%, monuron 80%, and linuron 50%, each at 4# + wetter, provided good control of P. maximum. It is recommended that diuron, which gives more effective control of P. maximum before emergence than does monuron, and is a more economical treatment than linuron, should be applied to vigorously growing plants before flowering, while excessive spray run-off into the growing point of young cane should be avoided. Low-volume sprays of diuron are noninjurious to Herbert River cane cv., but may cause some temporary leaf mottling in the cv. Q.57 and Q.68.

Cyperus rotundus. CP 31675 (6-t-butyl-a-chloro-o-acetotoluidide) evaluated for the control of C. rotundus caused a favourable growth response in cane. The addition of morphactin to various phenoxyacetic acid herbicides at ratios of 1:20 and 1:12 failed to improve their activity against C. rotundus.

Sorghum halepense. On a non-cropped site, at least 19# was required to achieve reliable control of S. halepense with bromacil. In a trial at Giru, bromacil at rates ranging from 3.2 to 25.6# disked into the soil provided excellent control; in a trial at Airville, intensive cultivation and roguing for 2 years enabled cane to be planted on a site previously infested with S. halepense.

Heliotropium amplexicaule. In plant cane, high volume sprays of picloram ±2,4-D or 2,4,5-T and 2,4,5-T alone applied in March (Dosage rates not stated) provided top kill of H. amplexicaule and suppressed regrowth before the onset of winter. On follow, a granular formulation of picloram + 2,4-D incorporated into the soil by hoeing 2 to 3 in. deep reduced % emergence and caused chlorosis of emerged plants when applied at 9 oz/ac, but was ineffective at 2, 4 and 6 oz/ac.

Weed control in drainage ditches. In trials in ditches in the Ingham area, mist sprays of paraquat at 3 oz/ac and sodium arsenite at 3.8# in 15 gal water applied to run-off desiccated P. purpurascens,

Eichhornia crassipes, Cyperus novaehollandiae and Scleria poaeformis sufficiently to allow burning off 8 to 10 days later. Boom sprayer and mist blower applications of 2,4-D amine at 2.5# + 0.5% wetter, with a follow-up application 3 to 4 weeks later, controlled E. crassipes. Both C. novaehollandiae and S. poaeformis were killed by spraying to run-off with the amine and Na salt formulations of 2,4-D at 2.5# in 50 gal water, but tolerated picloram + 2,4-D at 2 pints/ac, fenoprop at 3 pints/ac and low volume sprays of 2,4-D formulations. Bromacil at 16# and A 324 (bromacil 26% + 2,4-D Na 6.8% + dalapon Na 47.5%) at 25# controlled all species, except Ageratum spp. Cyperus iria and P. purpurascens.

Herbicidal toxicity to cane. In a replicated field trial carried out during lush growing conditions, ratoons cv. N.Co310 suffered reductions in cane yield of 28.8% following foliar applications of dalapon Na at 2# and 19.3% following soil applications of TCA at 50#. In a trial in the Lower Burdekin, aerial applications of 2,4-D amine at 30 oz/ac on vines (species not stated) in standing cane cv. Q.80 caused stem distortion, premature shooting of the eves and swelling at the root bands. In a further trial, 2,4-D amine at 10 oz/ac killed the vines without injuring the cane; stalks taken from the treated crop and used as stock showed a retarded rate of germination, but produced stands as even as did untreated control plots. -Weed Abstr. 16(3),1967.

58. BURKILL, I.H.

1966. Eichhornia crassipes-Utilization. In: A Dictionary of Economic Products of the Malay Peninsula Vol. 1, 1966, 906-907.

The young leaves, petioles, and inflorescences are sometimes eaten steamed or cooked in Java, but seem unpleasant to eat, as they cause an itching, even when cooked (Ochse, Vegetables Dutch E. Ind. 1931 p. 612)

The Chinese use it for fattening pigs, not only in Malaya, but in their own country and in Indo-China. They cultivate it in tanks for this purpose, and encourage it in fish-ponds, where the fish find food among its roots. Only when it spreads into sluggish rivers, it becomes a pest. Legislation was introduced in the Federated Malay States in 1914, and in the Straits Settlements in 1925, for the purpose of controlling it. Malaya in this merely followed an example set elsewhere, for country after country has declared against the plant; firstly the United States, where it choked navigable rivers in Florida, then Australia, Indo-China, and India.

The plant gathers into itself a great amount of potash, and this property makes it burn readily, when killed, giving an ash good for manuring. Without burning it is also useful. However, by alternate layers of the plant and soil, obtained a very good compost (Agric. Journ. Ind. 20:395,1925). It is related that Chinese, in their own country, in the autumn gather it and burn it in the fields to enrich the soil.

During eradication operations in Bengal, it was possible to get chemical manufacturers to buy the ash at a rate fixed by the amount of potash present. Finlow and McLean (Bull. 71, Agric. Res. Instit. Pusa. 1917) found by analysis, that rotted water-hyacinth is about as rich as farmyard manure, of the same water-content, in nitrogen, phosphoric acid and lime, and contains several times as much potash.

Luxuriant plants from Dacca produced the greatest amount of potash. Later analyses made upon ash from Burma (Bull. Imp. Institut. 19:460, 1921) showed a smaller percentage of potash, and analyses made in Malaya gave, in some cases, an equally low figure, but in others a higher figure. It is evident that the return varies considerably (Day in Agric. Bull. F.M.S. 6:309,1918). It is suggested that the most vigorous plants hold the greatest percentage of potash.

The potash is present as potassium-chloride. This is interesting, for in wood-ash it is commonly present as potassium-carbonate. As water very readily takes the potassium-chloride from the ash the salt can be extracted easily for sale, but the process would scarcely be economical, working on such low-grade material as the ash obtained in Burma.

There is fibre in the stems, which can be made into twine, and fibre used as a substitute for jute; but it has not become commercial; nor can it take any but an inferior place amongst fibres for cordage. Decortication is costly (Bull. Econ. Indochine, 25, Renseignm., p. 205, 1923).

The native paper-makers of Indo-China have used it a little for making thick cardboard (Crevost and Lemarie in Bull. Econ. Indochine, 21:837,1919). Tested in Europe, it was found possible to make a brown wrapping paper of fair quality, but the yield was only half of what straw returns (Bull. Imp. Institut. 24:267,1926).

In Kedah the flowers are regarded as a medicine for the skins of horses.

Ridley (Agric. Journ. Straits and F.M.S. 5:117,1906) says that he observed the flowers being hawked in the streets of Singapore, but does not say for what purpose.

59. BURKILL, I.H.

1966. Eichhornia crassipes-Way of living. In: A Dictionary of Economic Products of the Malay Peninsula Vol. I, 1966, 905-906.

A small genus of water-plants of the family Pontederiaceae, native of South America, from whence the following species has been distributed to most parts of the tropics.

E. crassipes, Solms. WATER-HYACINTH; Kěměling tělur, Kěladi bunting, Bunga jamban (from its luxuriant growth near latrines); in Siam Paktop chava.

A floating plant forming dense masses and rapidly covering still, warm water, in climates which suit it. The lowlands of the Malay Peninsula have such a climate, and it spreads over tanks, and into slow-flowing rivers, reproducing itself with great vigour. Hill-streams carry water which is too cold for it, so that it has always died in the Waterfall Gardens, Penang, when attempts have been made to grow it. If the water is shallow it roots in the mud under the water but rooting is unusual and unnecessary to it. It is recorded that in many South American rivers, which it occupies, the floods of the rainy season disperse the great masses accumulated during the dry season, and line the banks with stranded plants.

Its blue flowers are of great beauty, and it has been cultivated in Europe for their sake for a century and a half. Its rapid spread through the eastern tropics has taken place recently, this being its history. It was brought to Java in 1894 (K. Heyne, Nutt. Plant Ned. Ind. ed. of 1927, p. 435), to Tonkin in 1902, and about 1902 it

reached southern China also: the records are not clear from what country. It was seen in Hong Kong by some one who admired its beauty, and taken from that colony to Ceylon. Very soon it was taken also to northern India, where it found the sluggish rivers of eastern Bengal ideal places for its growth. From Hong Kong, as Holttum has ascertained, a Chinese resident in Singapore brought it into the Settlement in 1903 and grew it in his garden in Balestier Road. From his garden it was brought into the Botanic Gardens, where it throve exceedingly. It was taken from the Gardens by Chinese villagers of the Bukit Timah road, who made successful feeding experiments with it on their pigs, ending in its general adoption for the purpose.

60. CABRERA, A.L.

1964. Las plantas acuaticas. (Aquatic plants). Editorial Universitaria de Buenos Aires, (rev. ed.) 94 p. (Span; Univ. Buenos Aires, Argentina)

An illustrated booklet on the aquatic and amphibious plants of Argentina which includes botanical information on such species as Eichhornia crassipes, Salvinia auriculata, Pistia stratiotes, Marsilea concinna, Alternanthera philoxeroides and Ceratophyllum demersum. -Weed Abstr. 16(5),1967.

61. CHADWICK, M.J. and OBEID, M.

1966. A comparative study of the growth of Eichhornia crassipes Solms, and Pistia stratiotes L. in water culture. J. Ecol., 54:563-75. (Bibl. 39; Dept. Bot., Univ. Khartoum, Sudan)

E. crassipes and P. stratiotes were grown in water culture at different pH levels. In one experiment the pH levels 3, 4.3, 5.6, 6.9 and 8.2 were maintained in either a modified Long Ashton solution or in tap water. In the second experiment, pH levels of 4, 5.5 and 7 were in combination with N levels of 1.5 and 2.5 ppm.

Species performance was measured in terms of total dry wt. yield, number of plants produced and mean dry wt. per plant. Judged in terms of total dry wt. yield, the two species had very different pH optima; E. crassipes yielded best at approximately pH 7 and P. stratiotes at approximately pH 4. The former species produced more plants but of approximately the same size under optimum conditions when compared with growth at other pH levels. P. stratiotes produced a considerably greater number of plants at the optimum level than at others but these were smaller. In both species increase in N level caused a linear increase in both total dry wt. yield and plant number but had little effect upon mean wt. per plant. The effect of solution concn. could not be entirely attributed to a N effect.

The results are discussed in terms of the growth of E. crassipes in the Sudan Nile system and elsewhere, and the reported antagonism between the two species. -Weed Abstr. 16(5),1967.

62. CHOKDER, A.H.

1968. Further investigations on control of aquatic vegetation in fisheries. Agric. Pakist., 19(1):101-18. (Bibl. 60, Fresh Water Fish. Res. Unit, Kaptai, Chittagong Hill Tracts, E. Pakistan).

See also Weed Abstr. 16:181. The problem of weed infestation of water is reviewed from the point of view of fish farming. The life history and ecology of 2 floating weeds (Eichhornia speciosa

and Pistia stratiotes) and 4 submerged species (Hydrilla verticillata, Vallisneria spiralis, Najas graminea and Ceratophyllum demersum) was studied in the Dacca area. Control of submerged plants with herbivorous fish (see Abs. 243) and by shading with floating plants is described. 2,4-D at 4# was effective against E. speciosa during hot months; up to 16 ppm. controlled submerged plants but was expensive. Fertilizing with $N_{10}P_6K_4$ (after cutting submerged weeds) to encourage algal bloom was effective. E. speciosa contained about 25% potash and 40-50% cellulose indication possible utilization for power alcohol production and paper pulp manufacture. -Weed Abstr. 19(1),1970.

63. CHOKDER, A. H. and ANWARA BEGUM.

1965. Control of aquatic vegetation in fisheries. Agric. Pakist., 16(2):235-47.

Small-scale trials of various methods of killing weeds in fish ponds, conducted in E. Pakistan, indicated that manual control may partly be replaced by the use of mechanical implements such as special saws. Shading by floating weeds killed submerged species. Promising results against certain weeds were obtained with herbivorous fish such as carp, but not with Tilapia or with ducks. Submerged plants may also be controlled by encouraging the growth of unicellular algae by means of fertilizer mixtures or organic products such as mustard cake. Copper sulphate at 1 ppm killed algae; a 25 ppm concentration killed some higher aquatic weeds but is too toxic to fish. Control by 2,4-D compounds was effective against Eichhornia and Pistia but proved too costly for use against submerged weeds. Photos. 25 refs. -Trop. Abstr. 22(2),1967.

64. COHEE, P.R.

1967. The Hercules invert spray system. Hyacinth Contr. J., (6):8-9. (Bibl. 1; Hercules Inc., Orlando, Florida).

The sprayer described is designed for mounting on a land vehicle or boat for the hand-gun application of invert water-in-oil emulsion herbicide sprays. A simple, self-metering system is incorporated and provision made for recirculation before inversion during spray cut-off. Spray volumes may be reduced by using multiple stream nozzles, though adequate coverage of water hyacinth (Eichhornia crassipes) is achieved with 80 gal/ac applied through a single stream nozzle. -Weed Abstr. 17(4),1968.

65. CONNER, J.W. and others

1964. Translocation of amitrole-T and 2,4-D in water hyacinth. Abstr. 1964 Mtg. Weed Soc. Amer., 101 p.

Field experiments showed that amitrole-T controlled water hyacinth and was superior to 2,4-D. The addition of fenac to amitrole-T gave more rapid top-kill. Typical amitrole-T injury symptoms were observed in offshoots not directly treated.

In a study to determine the relative mobilities of 2,4-D and amitrole-T ± fenac in water hyacinth after separate treatment of mother plants or offshoots, but with the connecting stolon remaining intact, 2,4-D was found not to be translocated in either direction in amounts sufficient to affect the untreated plant. Amitrole-T was translocated, however, with resultant chlorotic symptoms and eventual death of the attached untreated plant. Translocation of amitrole-T ± fenac occurred more slowly, but resulted in more rapid kill of the plant directly treated. -Weed Abstr. 14(2),1965.

66. COOREMAN, J.

1959. T. telarius (Acari, Tetranychidae) a parasite of water hyacinth (E. crassipes). Bull. Agric. Congo Belge, 50(2):395-401. (bibl. 10, illus., Flemish summary)

It is thought that T. telarius, which severely damaged plants of water hyacinth grown in laboratory aquariums in Belgium, could be used for the biological control of this weed in the Belgian Congo. -Field Crop Abstr. 13,1960.

67. COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH, NEW DELHI

1952. Eichhornia crassipes - Chemical Control. In: The Wealth of India, Raw Materials, Vol. III, 1952, p. 132.

The use of chemicals, such as copper sulphate, lead nitrate and sodium arsenite has been suggested for the eradication of water-hyacinth. The minimum concentration of copper sulphate lethal to the plant is 0.018%; at this concentration fish and other fauna are affected. Further, calcium oxalate which is set free by the raphides of the leaves counteracts the effect of copper sulphate. In regions where infested water is used for drinking purposes by men or cattle, the use of poisonous chemicals for eradicating the weed is dangerous. In several States of America, the use of arsenites has been prohibited by law. (Parija, Loc. Cit.; McLean, Loc. Cit.; Vaas, Loc. Cit.)

Success in the practical control of water-hyacinth has been attained by the use of selective weedicides. 2,4-Dichlorophenoxy acetic acid applied in the form of spray at the rate of 8 lb. of 2,4-D acid equivalent per acre, has given satisfactory results. Esters of the acid and amine salts are equally effective. A somewhat higher dosage is recommended for the killing of older plants. 2,4-D is absorbed by the leaves and transferred to the growing meristematic tissue. The first conspicuous symptom of herbicidal action appearing within 2 days of spraying is an abrupt epinasty or downward bending of the upper part of the leaf petiole. This is followed by discolouration and death in about 3 weeks and the plant mass sinks to the bottom. Practical control is effectively accomplished by applying the initial spray when the plants are not in an active state of growth. A sufficient coverage of spray is essential and where the growth is dense, a second spraying is usually necessary. 2,4-D causes greater injury under shade conditions than in full sunlight and may be applied with advantage in the evenings rather than in the mornings. Close watch is maintained and every surviving plant is sprayed to ensure total eradication. Within the concentration employed, 2,4-D is harmless to fish and other aquatic fauna. It is also harmless to men and cattle. Eradication by the use of weedicides is cheaper and more effective than mechanical eradication. Excellent results have been reported from many countries by the use of 2,4-D (Hitchcock et al., Contr. Boyce Thompson Inst. 15, 1949, 363; Vaas, Loc. Cit.; Joshi,et al., Indian Fmg. 11, 1950, 545; Hildebrand, Science, 103, 1946, 477; Chem. Abstr. 43, 1948, 2714)

Methoxone (4 chloro-2-methylphenoxyacetic acid) has been employed either as dust (1%) or as solution spray (.01%), with satisfactory results. Santobrite (sodium pentachlorphenate) applied in a concentration of 5 ppm. has been found to be effective in arresting the growth of water-hyacinth without any ill effects to other aquatic life; a dosage of 80 ppm. is required for complete eradication. (Kar, Sci. & Cult. 12,1946-47, 545; Thomas & Srinivasan, Indian Fmg. 1949, 103; Hirsch, Bot. Gaz. 103,1941-42, 620)

68. COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH, NEW DELHI
1952. Eichhornia crassipes - Eradication. In: The Wealth of India, Raw Materials, Vol. III, 1952, 131-32.

Few other weeds have cost so much trouble and money as water-hyacinth and its eradication has received serious attention in many countries. In view of the amazing rapidity with which the weed spreads, eradication can be effective only if all chances of re-infestation are eliminated. The primary sites of occurrence of the weed are inland waters and in tackling the problem of eradication, greater attention must be directed to them and the weed must be totally destroyed in its inland homes during the dry season (Basak, Loc. Cit.)

Various methods for the eradication of water-hyacinth have been suggested and tried from time to time. In Bengal, the eradication of water-hyacinth has been made compulsory by legislation within notified areas. Special water-hyacinth weeks are organized during which parties of workers clear infested areas, heap them up on banks to dry for eventual use as manure. In Assam, provisions are made in Municipal and Local Self Government Acts to enforce land-holders to eradicate water-hyacinth. The Madras Agric. Pests and Diseases Acts, 1919, makes the destruction of the weed obligatory on the part of the owner or the occupier of the land, channel or pond. In U.P., the Government have from time to time assisted in the removal of water-hyacinth by grants for compost making. The benefits resulting from such measures, however, have been comparatively limited. (Agric. Live-Stk. India 8, 1938, 65; Clarke, Indian Fmg., 2, 1941, 127; Tadulingam & Narayana, 307)

69. COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH, NEW DELHI
1952. Eichhornia crassipes - Harmful. In: The Wealth of India, Raw Materials, Vol. III, 1952, p. 131.

The ravages caused by the weed are extensive. It impedes run-off in streams and promotes back-water and flood conditions in many areas. It also affects drainage of cultivated lands by choking off drainage channels by its dense growth. The wild life resources of lakes and rivers are affected. The mat-like spread cuts off air and sunlight from the water below; decaying plant parts affect the oxygen tension and therefore fish life. It is stated that the rafts of water-hyacinth break lose, and driven by the wind, move back and forth tearing up and destroying valuable submerged food plants. Water-hyacinth has invaded paddy fields in some areas and rendered them unproductive. It has displaced many aquatic fodder grasses. The weed obstructs wave action in the water and interferes with the activities of birds; it hinders the use of larvicides and other anti-mosquito measures. Navigation is hazardous in water-hyacinth-infested waters. Decaying plant parts pollute the atmosphere and the sources of drinking and bathing water. It is reported from U.S.A. that water-hyacinth "rafts" interfere with landing facilities for sea planes and constitute a hazard for the taking off and landing of amphibious and sea-water aircrafts (Penfound & Earle, Ecol. Monogr. 18, 1948, 449; Basak, Loc. Cit.)

70. COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH, NEW DELHI
1952. Eichhornia crassipes - Introduction. In: The Wealth of India, Raw Materials, Vol. III, 1952, p. 131.

Water-hyacinth was introduced into India as an ornamental plant nearly half a century ago. It spread rapidly and is now found practically all over the country. It is a serious pest in Bengal, covering by its dense growth vast surfaces of rivers, lakes and ponds. It is estimated that about 30,000 acres of once clear water surface in West Bengal is infested with this noxious weed, the infested area being much larger during the monsoon months (Basak, Water-hyacinth Compost, Directorate of Agriculture, West Bengal, 1948).

71. COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH, NEW DELHI
1952. Eichhornia crassipes - Propagation. In: The Wealth of India, Raw Materials, Vol. III, 1952, p. 130.

The growth and spread of water-hyacinth in tropical waters is prolific and so dense that in some areas in Bengal, it is possible to walk over the floating mass. Some of the features which contribute to the menacingly rapid spread of the plant are: ability to grow on open sheets of water; high rate of ease growth by stolons; low demand on environment; ease of movement due to the bladder-like petiole which makes the plant float, the leaf blade acting as a sail; and easy dissemination of seeds by wind or water current. (Vaas, Contr. Gen. Agric. Res. Sta., Bogor, No. 120, 1951).

72. COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH, NEW DELHI
1952. Eichhornia crassipes - Raw material for industry. In: The Wealth of India, Raw Materials, Vol. III, 1952, 133-34.

Attempts have been made to utilize the plant as a raw material for paper, plastics and other commercial products but so far no industry based on water-hyacinth appears to have been established. The manufacture of paper from the dried weed has been attempted in Bengal. The fibrous stem, constituting about 40% of the whole plant, is suitable for paper making. The addition of jute or cotton fibres to the extent of 8-10% on the weight of the pulp is considered necessary as the paper prepared from the stems alone is translucent. The pulp may be pressed into boards and used for papier mache or mixed with cement and whiting and moulded into tiles. A plastic material suitable for the production of moulded articles and boards has been prepared from water-hyacinth. Attempts to produce a blue black writing ink from the flowers did not prove successful as the colour was not stable. In Cochin-China, a fibre has been extracted from the weed. It is unsuitable for spinning, but may be used for wicker and basket work and as substitute for cane for chair bottoms. These and other attempts to utilise the weed, reported from time to time, e.g. production of straw-boards and material for upholstering, have not led to any commercial developments. (Azam, Sci. & Cult., 6, 1941-42, 656; 11, 1945-46, p. 182; McLean, Loc. Cit.; J. Madras Agric. Stud. Un., 5, 1917, p. 21; 7, 1919, p. 149; Vaas, Loc. Cit.).

The possibility of using the dried weed for the production of power gas and power alcohol has been considered. Three methods have been suggested, viz. saccharification by acid digestion and subsequent fermentation, gasification by air and steam with recovery of ammonia, and bacterial fermentation and utilization of the evolved gas for power production. Potassium chloride (0.1 ton of KCL per ton of dry hyacinth) is recovered in all the 3 processes. Starting from 1 ton of dried water-hyacinth, 13 gallons of ethyl alcohol and 0.2 tons of

residual fibre (7700 B.t.u.) are obtained by the first process. Gasification by air and steam at 800° gives per ton of dried material, 82-116 lb. of ammonium sulphate and 40,000 cu.ft. of gas (142.8 B.t.u.) containing: hydrogen, 16.6; methane, 4.8; carbon monoxide 21.7; carbon dioxide 4.1; and nitrogen 52.8%. Bacterial fermentation gives per ton of material 26,500 cu.ft. of gas (600 B.t.u.) containing: methane 51.6; hydrogen 25.4; carbon dioxide 22.1 and oxygen 1.2%. The commercial possibilities of the processes have not been proved. The high moisture content (C 95%) of the green plant adds considerably to the cost of transport and drying, and water-hyacinth appears to have but limited possibilities for use as an industrial raw material. (Sen., Chem. Abstr. 25, 1931, 5269); Sen & Chatterjee, J. Indian Chem. Soc. 8, 1931, p. 1).

73. COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH, NEW DELHI

1952. Eichhornia crassipes - Utilization-Manure. In: The Wealth of India, Raw Materials, Vol. III, 1952, 132-33.

The utilization of water-hyacinth as a manure has received special attention in India. The fresh plant contains approximately: moisture, 95.5; organic matter, 3.5; nitrogen 0.04; ash 1.0; P_2O_5 0.06; and K_2O 0.20%. The dried plant contains: Organic matter, 75.8; nitrogen 1.5; ash 24.2%. The ash contains: K_2O 28.7; Na_2O 1.8; CaO 12.8; Cl 21.0; and P_2O_5 7.0%. The figures show that water-hyacinth is exceptionally rich in potassium and is of considerable value as potassic manure. (Finlow & McLean, Bull. Agric. Res. Inst., Pusa No. 71. 1917)

The potash content of water-hyacinth varies with the conditions under which it grows. The healthier and taller the plant, the greater the potash content. Plants growing on land or in shallow water are usually stunted and their potash content is low. Plants are generally most vigorous in September-October when they are also rich in potash. The stems are richer in potash than the leaves and the leaves are richer in potash than the roots. (Finlow & McLean, Loc. Cit.)

For use as manure, water-hyacinth may be burnt and the ashes used for fertilizing the soil, or it may be composted. The laterite soils of the old alluvium of Bengal and some types of silt comprising the new alluvial tracts are deficient in potash, phosphate and lime, and water-hyacinth, either rotted or ashed, is a valuable manure for them. For light, well drained soils, the rotted material may be preferred; for heavy low-lying lands the ash may be used with advantage. The ash which forms only 1% of the weight of the fresh plant is convenient for transporting from place to place, but both nitrogen and organic matter, which can be conserved by composting, are lost during burning. (Finlow & McLean, Loc. Cit.)

Many farmers in Bengal use dry hyacinth as fuel. The usual practice is to collect the plants at the beginning of the cold weather, leave them on high land to dry and use the dried material along with jute sticks and refuse as fuel. The ashes are subsequently used as manure. Attempts have been made to extract potassium chloride from the ash, but as a commercial venture, the use of water-hyacinth ash as a source of potassium salts is not likely to be renumerative. (McLean, Loc. Cit., Bull. Imp. Inst., Lond., 1921, 19, 460)

Water-hyacinth mixed with earth, cow dung and wood ashes in the Chinese compost fashion gives a compost in about 2 months. Other methods of composting, varying in details, have been worked out. It is necessary to use wilted rather than fresh plants in the compost heap as, due to the high water content, the juice from the fresh plants is expelled and lost during stacking. (Howard, Agric. J. India, 1925, 20, 395; Watson, Indian Fmg., 1947, 8, 29; Basak, Loc. Cit.)

Hyacinth compost contains on an average (on dry matter basis): nitrogen 2.05; phosphorus (as P_2O_5), 1.1; potassium (as K_2O), 2.5; calcium (as CaO), 3.9%; and C/N ratio, 13. Bulk for bulk, hyacinth compost is twice as rich as town compost and four times as rich as farmyard manure in potash. It is eminently suitable for jute and rice fields, for vegetable gardening and fruit growing. It can be produced at low cost and large scale trials have demonstrated that water-hyacinth eradication through composting is not only practical but also renumerative. (Basak, Loc. Cit.; Howard, Loc. Cit.)

Fodder: Water-hyacinth has been used as pig fodder in Central and South China and in Malaya. In China, it is cultivated in fish ponds and used as fodder for pigs, the piggery washings being drained into the pond to fertilize the growth of hyacinth. The fish taken out from the highly polluted ponds are kept in masonry tanks for a few days, fed on wholesome diet and then consumed as human food. (Hora, Sci. & Cult., 1951-52, 17, 231)

The weed is also eaten by cattle and horses. As a fodder plant, water-hyacinth is inferior to the common fodders in use. It contains (on dry wt. basis): nitrogen, 0.97-2.57; potash, 5.0; chlorine, 3-4; CaO, 3.5; MgO, 0.96; and P_2O_5, 0.36%; total digestible nutrients 41.34; and starch equivalent, 34.25 lb. per 100 lb. In nitrogen content, water-hyacinth is comparable to other green fodders. It is richer than Napier and Guinea grasses in lime and magnesia, but poorer in phosphate. In digestible nutrients it compares favourably with Napier and Guinea grasses and is superior to rice straw. In palatability, however, it is inferior, due probably to the exceptionally high potash and chlorine contents which also affect the general mineral metabolism of the animal. Water-hyacinth may be used in moderate quantities in combination with cake or concentrate or with other feeds but it can hardly occupy a high place as fodder. (Chatterjee & Hye, Agric. Live-Stk. India, 1938, 8, 547)

It was recently reported from Tinnevelly (Madras State) that water-hyacinth is being used as feed for buffaloes, 15 lb. of fresh weed being given per buffalo per day. The milk yield is reported to be enhanced by 10-15%, but the milk is watery and the extracted butter lacks in consistency and flavour. The average yield of fodder is estimated at 60 tons per acre per annum. (Madras Agric. J., 38, 1951, 27)

74. COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH, NEW DELHI

1952. Eichhornia Kunth (Pontederiaceae). Eichnornia crassipes Solms. Syn. E. speciosa Kunth Water-hyacinth. In: The Wealth of India, Raw Materials, Vol. III, 1952, p. 130.

A perennial aquatic plant, floating in water or partly rooting in mud in shallow waters, with numerous long fibrous roots, short leafy stem and showy flowers. Leaves in rosettes, spoon or paddle-

shaped with rounded apex, 2-8 inch diam. petioles turbinately swollen and spongy, enabling the plant to float. Inflorescence spicate, 6-10 inch long, with numerous (3-35) flowers; flowers mauve or lilac coloured, funnel-shaped, 1-1.5 inch long; the peduncle of the inflorescence bends over immediately after flowering and the withering flowers are thus pushed under water, fruit a capsule with numerous seeds.

The plant withstands a considerable, amount of drought and is capable of growing as a land plant. It is sensitive to frost and cannot subsist in saline water.

Water-hyacinth is propagated mainly vegetatively by the creeping stolons, from the tips of which arise new plants; these get readily separated from the parent and begin an independent life. Rooted plants are easily washed away and floating plants may as easily send down roots into the soil when they reach shallow water. Birds have also been reported to help dispersal by carrying young rosettes on their legs. A single plant has been known to spread over an area of 600 sq. meters in a few months. Water-hyacinth may also be propagated by seeds. The plant flowers nearly throughout the year and fertile capsules appear towards the end of October or November. Very few seeds are formed in a spike. The seeds fall on the matty platform or settle down on the soil at the bottom or on the margin and remain viable for a long time. (McLean, Agri. J. India 17, 1922, 23; Parija, Indian J. Agric. Sci. 4, 1934, 399; Agric. Live-Stk. India, 5, 1935, 124; Bose, Trans. Bose Res. Inst., 3-4, 1920-21, 786)

75. DARTER, I.E. and WRIGHT, N.
1963. Paraquat: a new herbicide and desiccant. Pest. Abstr. C., 9(3):203-6, bibl. 1. (I.C.I. Ltd., Jealott's Hill Res. Sta., Bracknell, Berks, England).

The chemical and physical properties, toxicity and mode of action of paraquat are reviewed, together with its uses (particularly in tropical agriculture) for weed control, pre-harvest desiccation in sugar beet and killing oil palm (Elaeis guineensis). Paraquat is being used commercially in Ceylon for the control of aquatic species such as Salvinia auriculata, Eichhornia crassipes and Pistia stratiotes. -Weed Abstr. 12(6),1963.

76. DAS, R.R.
1969. A study of reproduction in Eichhornia crassipes (Mart), Solms. Trop. Ecol., 10(2):195-8. (Bibl.13, Banaras Hindu Univ., Varanasi-5, India)

Studies showed that seeds are produced naturally only during September-November. The seeds fail to germinate when submerged but can be made to germinate by aerating the water and scarifying the seeds indicating requirement for oxygen. The rhizomes are capable of rapid multiplication and exhibit apical dominance. Injury or desiccation in mud does not adversely affect the viability of rhizomes, which helps the plant in tiding over adverse conditions and promotes the wide spread of the species. -Weed Abstr. 20(5),1971.

77. DATTA, R.K. and others
1966. Studies on leaf proteins-preparation of protein concentrate from leaves of water hyacinth. Sci. Cult., 32(5):247-249. - Biol. Abstr. 48,1967.

78. DAWOOD, I.K. and others

1965. Herbicide trials in the snail habitats of the Egypt 49 project. Bull. Wld. Hlth. Org., 32:269-87. (Bibl. 5; E., fr).

Trials were undertaken in Egypt to study the action of different herbicides and their combinations on aquatic vegetation which provides a habitat for snail hosts of Schistosoma haematobium, S. mansoni and Fasciola sp. in canals and irrigation ditches. 2,4-D amine applied at 0.43 kg/1000 m^2 was effective against mature Eichhornia crassipes in larger canals and drains. Reglone (diquat) at 0.45 l./1000 m^2 was effective against young growths of E. crassipes and could be used with advantage in laterals and field channels between broad-leaved crops which might otherwise be adversely affected by 2,4-D drift and vapour. Dowpon (dalapon sodium) at 2.1 kg. in 4.5 l. diesel oil/ 1000 m^2 has been found effective against Typha ungustata, Phragmites communis and Scirpus inclinatus, and Dowpon 2.1 kg./m^2 + Weedazol (aminotriazole) 1.3 kg. in 4.5 l. diesel oil/1000 m^2 is very effective against Panicum repens. In laboratory tests all the herbicides gave evidence of some activity against mollusc eggs. It was shown that the use of herbicides is less expensive than former manual methods and also reduces the risk of bilharziasis infestion among agricultural workers. -Weed Abstr. 16(6),1967.

79. DAZO, B.C. and others

1966. The ecology of Bulinus truncatus and Biomphalaria alexandrina and its implications for the control of Bilharziasis in the Egypt-49 project area. Bull. World Health Organ., 35(3):339-56.

The respective vectors of the 2 forms of bilharziasis in Egypt do not have the same ecological distribution. B. truncatus is most abundant in large canals, and decreases in density as the water approaches and flows into drains. B. alexandrina is more abundant in the presence of aquatic vegetation, but they differ in their respective associations with the water hyacinth, Eichhornia crassipes. B. alexandrina reaches maximum abundance in the presence of this plant, but B. truncatus is as uncommon in the absence of plants as in the presence of plants as in the presence of E. crassipes. Calculation of life-table parameters from field data shows that, under optimum field conditions, both species can double their populations in 14-16 days. The reproductive rates of both species are greatest in March and the death rates in midsummer. The observed peak densities in May and June give a false impression of optima because of under collection of young snails which are most abundant in March and April. Control operations should take advantage of the findings on population parameters. A single area-wide treatment with molluscicide in April is recommended. During the remainder of the year, search for isolated foci of snail breeding and individual treatment of these will effect large savings of chemical and will be effective in controlling the transmission of the parasites. -Biol. Abstr. 48,1967.

80. DE KIMPE, P.

1956. Campaign for the destruction of E. crassipes. Proc. 2nd. Symp. Afr. Hydrobiol. Inland Fish., 1956, C.S.A.S.S. Publ. 25), p. 125.

In the campaign against E. crassipes in the Congo and certain of its tributaries, the chemical used is 2,4-D amine at 0.7%. The programme has 3 phases. In the first, an attempt is made to spray all the plants; in the second phase which should not begin until 4-5 weeks after the first, the plants which survived the first treatment are again sprayed; in the third phase, which continues over a long period, spraying is directed to keeping possible sites of reinfestation under control. The spraying is done by means of motor pumps installed on whaleboats equipped with 2 adjustable gunjets and also, in the less accessible places, by hand pumps on canoes. -Weed Abstr. 11(6),1962.

81. DECARY, R.

1965. Some spreading or noxious plants of Madagascar. J. Agric. Trop. Bot. Appl., 12(6/7/8):343-350. (Bibl. 8; Fr).

Information is given on the following species; 1. Mucuna pruriens. Widespread in N.W. Sakalaya, up to altitudes of 700-800 m; its irritating hairs may be carried by the wind; cannot be controlled by burning common in Reunion. 2. Lantana camara var. aculeata. Introduced some time after 1901, now covers thousands of hectares in all the eastern region and in Imerina; eradication appears impossible but further spread could be prevented; is also a weed in Reunion. 3. Rubus mollucanus. Fairly recently introduced from Reunion; appears to be spreading. 4. Agave ixtli. Introduced as a fibre plant during the 19th century, it has spread in the subdesert areas of the south-west and south, where it was originally planted for protective hedges; further planting took place after 1925 when the populations of Opuntia monacantha were destroyed by the introduced moth, Cactoblastis cactorum; areas formerly occupied by O. monacantha have been colonized by A. ixtli. 5. Acanthospermum hispidum. Recently introduced and now widespread along paths, roads and in the neighbourhood of dwellings. 6. Tribulus terrestris, common in drier sandy areas at lower altitudes; the related T. cistoides is less widespread. 7. Clidemia hirta. Seed from Java was sown in a botanic garden near Tamatave circa 1915; it has formed spiny thickets in all the Tamatave region. 8. Erigeron naudini. Of American origin, it has become a widespread arable weed during the last 40 years, but is not of major importance. 9. Cyperus rotundus. Common in rice and arable fields up to an altitude of 1400 m, but not a major weed. 10. Pteridium aquilinum. Invades secondary bush, forming dense stands, particularly in the centre of the island and in the western boundary of the Plateaux region. It has spread owing to attempts to control it by burning. 11. Eichhornia crassipes. The most important water weed; introduced circa 1920 from Reunion as an ornamental; in 1928 a law was passed to prevent its spread, but proved impossible to enforce; large manual collection was attempted in 1947 and spraying trials (using 2,4-D) in 1951-2 gave variable results; despite continuing control measures the weed is now definitely established; a related mud-rooting species, E. natans, is not a weed. 12. Pistia stratiotes. Common on stagnant water at altitudes up to 1200 m.

Eradication campaigns have been undertaken for some years against Mundulea sericea (common in the Plateaux region and M. monantha (in the Ankaratra region) as they are widely used as illegal fish poisons. Derris trifoliata is used for the same purpose in

estuaries. Eradication campaigns were carried out in the 19th century against Cerbera venenifera and Erythrophleum couminga, ordeal trees, but they have now been abandoned. -Weed Abstr. 16(5),1967.

82. DENTON, J.B.
1967. Certain relationships between the chemical composition of aquatic plants and water quality. Proc. 20th Sth. Weed Conf., 354-62. (Bibl. 21; Alabama Dept. Conserv., Montgomery)
Analysis of Alternanthera philoxeroides, Myriophyllum brasiliense and Eichhornia crassipes harvested from polluted and non-polluted waters showed plant nitrogen, magnesium, potassium and sodium to vary considerably with the concn. of these elements in the water and bottom soil. Plant ash values varied with water hardness, while carbon content differed little with environment. -Weed Abstr. 18(2),1969.

83. DHAR, N.R. and GUPTA, B.S.
1965. Composition of water hyacinth in presence and absence of algae. In: Symposium on land fertility improvement by blue green algae. Nat. Acad. Sci. India Proc. Sect. A (Phys. Sci.), 35(3): 327-360. Illus. (recd. 1966)
Water hyacinth (Eichhornia crassipes) grows overywhere in great abundance and frequently its eradication is a big problem. Experiments have been carried on with water hyacinth for its composting and obtaining available N, phosphate, and potash from the compost formed by mixing it with different basic slag and the 3 algae, Chlorella, Anabaena and Tolypothrix. Experimental results show that these algae, specially Anabaena and Tolypothrix improve the quality of the compost from the N viewpoint. Phosphates markedly improve the N content when the water hyacinth compost is obtained by mixing it with basic slags. The trace elements present in the basic slags markedly improve the quality and the productive power of the water hyacinth compost. -Biol. Abstr. 48,1967.

84. DIAS, G.R.W.
1967. Eradication of water weed in Ceylon. Wld. Crops, 19(1): 64-8. (District Agric. Extention Office, Nugegeda, Ceylon)
Salvinia auriculata, a native of tropical America, appears to have been introduced to Ceylon in 1939 and had spread to cover 50,000 ac. by 1960. In 1961 the government took charge of the Salvinia control compaign. Paraquat (2 lb. cation per gal.) at 2-3 pints in 100-150 gal. water/ac. was found to be more effective and cheaper than the PCP in use until then. Follow-up treatments were necessary to effect eradication. Marshes were sprayed and drained to bring them into cultivation. For aerial application in marshes a noncorrosive formulation of paraquat was used at 1 oz. per gal. of water. A mixture of 1 oz. each of paraquat and 2,4-D ester per gal. of water was effective against S. auriculata, Eichhornia crassipes, Lamnochara flavis and Pistia stratiotes and is recommended for rice fields. -Weed Abstr. 16(4), 1967.

85. DIEM, J.R. and DAVIS, D.E.
1969. The enhancement of ametryne toxicity to water hyacinth with 2,4-D. (Abstract), Proc. 22nd Meet. Sth. Weed Sci. Soc., 359. (Auburn Univ. Agric. Exp. Stn., Alabama)

In a glasshouse study water hyacinth (Eichhornia crassipes) exposed for 30 min. to root treatments of ametryne at 15 and 30 ppm. was killed in < 2 weeks. E. crassipes was resistant to 2,4-D at 0.1 ppm. and moderately susceptible to ametryne at 1 ppm. but was killed by a combination of both. -Weed Abstr. 19(6),1970.

86. DIRECTOR OF AGRICULTURE, BRITISH GUIANA

1960. Rep. Dir. Agric. Brit. Guiana, 1960, p. 30.

Weed control. Simazine at 3-4# has given good control of broad-leaved weeds and o coryla vine (?), and dalapon of Imperata sp and Brachiaria sp., provided these grasses were irrigated before application.

Aquatic weeds. Manatees have successfully controlled shrimp grass (Luziola spruceana), water hyacinth (Eichhornia crassipes) and, to some extent, Cabomba aquatica in canals. Control of the movement of the animals is the main problem and the cost of handling them on sugar estates is prohibitive. They are less effective in shallow canals and do not like to be disturbed.

TCA or dalapon + 2,4-D is effective in killing-off canal weeds after draining dry, and subsequent admittance of water prevents re-growth. -Weed Abstr. 11(6),1962.

87. DRYDEN, W. and MILLER, T.W.

1962. Formation of an independent tax supported weed control district. Hyacinth Contr. J., (1):13-14.

The organization and implementation of a programme for the control of water hyacinth (Eichhornia crassipes) on the lower Gulf Coast in Florida through the formation of the Lee County Hyacinth Control District (=Board) is described. The programme is financed by means of a levy on taxable property and through grants from the State Game and Fresh Water Commission and the Central and Southern Florida Flood Control District. -Weed Abstr. 15(1),1966.

88. EUE, L. et al.

1969. The herbicidal activity of variously substituted 1,2,4-triazinones. (Proc.) 3rd Symp. on New Herbicides, Versailles, 125-40. (Bibl. 2; D, F; Farbenfabriken Bayer AG, Leverkusen, W. Germany)

The 1,2,4-triazinones described are photosynthesis inhibitors with a marked structure-activity correlation (see also Abs. 852) and possessing strong herbicidal activity pre- and post-em. Oral LD 50 values for warm-blooded animals are in all cases > 1000 mg/kg. The derivative 4-amino-6-phenyl-3-methylthio-4,5-dihydro-1,2,4-triazin-5-one gives good control of grasses and broad-leaved weeds; it is particularly selective in flax at 1.5 kg/ha pre-em. or 1 kg/ha post-em., but shows a somewhat narrow margin of selectivity in barley. 4-amino-6-cyclohexyl-3-methylthio-4,5-dihydro-1,2,4-triazin-5-one is also selective in flax, though rather less so than the 6-phenyl derivative, and has shown promise in preliminary trials for pre-em. use in maize, lupins, beans, peas, soybeans and potatoes at doses between 0.5 and 1.5 kg/ha according to soil type and level of rainfall. The compound can be used pre- and post-em. in pineapples at up to 2 kg/ha, while in aquatic situations good results are achieved with 0.5 kg/ha against Eichhornia crassipes and there is some activity against submersed species.

Compared with the cyclohexyl derivative, 4-amino-6-t-butyl-3-methylthio-4, 5-dihydro-1,2,4-triazin-5-one is generally more active and shows rather more favourable selectivity in soybeans, tomatoes and potatoes when applied pre-em. at between 0.4 and 1 kg/ha, but rates down to 4 kg/ha cause marked injury in top fruit and vines. This compound is suitable as a total herbicide at 5 to 10 kg/ha, though combined applications with triazines, ureas and uracils are recommended to increase persistence. Surprisingly, 4-amino-6- iso-propyl-3-methylthio-4, 5-dihydro-1,2,4-triazin-5-one shows little selectivity and rates >5 kg/ha are injurious to top fruit and vines, with stone fruit proving particularly susceptible. Doses of 5 to 10 kg/ha are required for total weed control, though, because of its relatively high water solubility (0.18%), the compound lacks adequate residual activity in rainy areas; excellent results are obtained, however, where it is applied in mixtures with urea, triazine and uracil herbicides. -Weed Abstr. 19(6),1970.

89. EVANS, A.C.

1963. The grip of the water hyacinth. New Scientist, 19:358, 366-8, bibl. 5.

The problem of Eichhornia crassipes and its control are reviewed and brief notes given on Salvinia auriculata and Microcystis toxicata. -Weed Abstr. 12(6),1963.

90. FERGUSON, F.F. and BUTLER, J.M.

1966. Ecology of Marisa and its potential as an agent for the elimination of aquatic weeds in Puerto Rico. Proc. 19th Stn. Weed Conf., 468-76. (Bibl. 31; Puerto Rico Field Stn., US Dept. Health, Education and Welfare, San Juan)

An extensive review is given of the ampullarid snail Marisa cornuarietis, its ecology and its potential as an agent for the control of aquatic vegetation. Of primary importance as an agent for the control of the snail intermediate host of schistosomiasis, Australorbis glabratus, it does, in some situations, show a readiness to consume algae and larger aquatic plants. Under laboratory conditions, Marisa consumes a wide range of vegetable foods including tomatoes, celery, lettuce, cabbage, carrots, dwarf arrowhead (Sagittaria subulata), water cress (Nasturtium officinale), Elodea sp. and Cabomba sp. In Puerto Rico, the snail fed on banana leaves, Hibiscus sp., Caladium sp. (both leaves and roots), various algal mats, floating fern, Eichhornia crassipes (root system and parts of the floats), water lettuce (Pistia stratiotes), Castalia ampla and a variety of common broad-leaved surface plants. The snail exhibits definite taste preferences readily consuming, for example, immature Pistia sp. but rejecting tough grasses, and eating Elodea sp. only as a last resort.

Field studies in Puerto Rico show that Marisa will destroy water lilies (Nymphaea sp.) and may be associated with Najas sp., Potamogeton fluitans (=P. nodosus), Salvinia rotundifolia, E. crassipes, Castalia ampla, Elodea sp., Ceratophyllum demersum, N. officinale, Chara sp., Nitella sp., Lemna perpusilla, filamentous green algae (including Spirogyra sp.), Typha angustifolia, Jussiaea angustifolia, Caladium sp. and Sagittaria lancifolia (=S. falcata).

Extensive laboratory and field investigations are necessary to determine the potential of Marisa as an agent for biological weed control. Any significant reduction of aquatic vegetation would be

likely to be achieved only with high population densities, but no special problems appear to condition its introduction into Puerto Rico. It appears well-adapted to most fresh-water habitats, including irrigation systems, thriving best in clear or only slightly turbid water, though limited mobility would appear to restrict its natural spread. -Weed Abstr. 16(6),1967.

91. FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
1965. Control of aquatic weeds. Rep. FAO Conf. Quelea Bird Wat. Hyacinth Control in Afr., Douala, Cameroon, 6-13. (Bibl. 8)
Loss assessment, control measures, co-ordination and exchange of information, quarantine measures and the need for co-operative control action are the topics discussed and which form the basis of recommendations. Trials on the use of 2,4-D and paraquat against water hyacinth (Eichhornia crassipes), the effectiveness of applications of paraquat at 1# and sodium arsenite 8-10 # for the control of Salvinia auriculata on Lake Kariba and the extent of infestations of Pistia stratictes are briefly reported on. It was recommended that research should be made into the biological control of E. crassipes and S. auriculata. -Weed Abstr. 16(1),1967.

92. GALLAGHER, J.E.
1962. Water hyacinth control with amitrol-T. Hyacinth Contr. J., (1):17-18, bibl. 3.
A report is given of studies on the control of water hyacinth with amitrole carried out between 1959 and '61 by D.E. Seaman at the US Department of Agriculture Aquatic Weed Research Laboratory, Fort Lauderdale, Florida, In field trials, a formulation of amitrole-T containing a 1:1 mixture of amitrole + NH_4SCN applied at 0.5-2 lb amitrole/ac was more effective and persistent, but less quick-acting than 2,4-D at 2-4 #, while in laboratory trials, amitrole-T appeared to be more readily translocated through the stolons to vegetative offshoots than was 2,4-D.
NH_4SCH appeared to have a synergistic effect when applied to E. crassipes in mixtures with amitrole. Increasing concentrations of NH_4SCN gave corresponding increases in control up to an apparent optimum ratio of 1 part amitrole to 2 parts NH_4SCN by weight. See also Weed Abstr. 11:439. -Weed Abstr. 14(6),1965.

93. GALLAGHER, J.E.
1964. Amchem aquatic weed control program. Hyacinth Contr. J., (3):8-9.
Desirable qualities of herbicides for the control of aquatic weeds are enumerated, with reference to several products of the enumerated, with reference to several products of the Amchem Chemical Company. They include 2,4-D for the control of cattails (Typha sp.) water hyacinth (Eichhornia crassipes) and Phragmites sp. and fenac as a soil applied treatment for the control of Potamogeton sp. -Weed Abstr. 15(2),1966.

94. GANGULY, S. and SIRCAR, S.M.
1964. Cell growth and metabolism of pea (Pisum sativum L.) internodes as affected by the growth substances from the root of water hyacinth (Eichhornia crassipes). In: Botanical Society of Bengal: Symposium of frontiers of plant science, Calcutta, India, 29-30 March 1964. Bull. Bot. Soc. Bengal, 18(1/2):83-86. Illus. - Biol. Abstr. 48,1967.

95. GLOOR, A.M. and GLOOR, R.P.

1950. Improvements in the manufacture of paper pulp and of paper; Australian Patent 138,426 .

A patent specification accepted by Department of Patents, Commonwealth of Australia, in August 1950, for a method of manufacturing facture pulp and paper from water hyacinth (Piaropus crassipes or Eichhornia crassipes) is presented.

The weed is gathered and fed to an afloat or on-shore processing plant, the former having the advantage of mobility. Fresh leaf stalks and leaves (optional) are used: roots (which reduce grade of pulp) may be discarded.

Conveyance of the weed through the figured invention apparatus is described by stages. In a digestor, it is boiled for 25 minutes at atmospheric pressure in KOH (5 to 10 Baume.). Contents of the digestor are passed to a separating tank where pulp is collected and the decanted solution reconditioned and recycled. The pulp is washed with water until neutral, squeezed to remove excess water and then sized with a 20% solution of dammar resin in ethyl alcohol (90%). Sized pulp is stirred to consistency by uptake of additional water. After possible tinting, pulp is run on to a revolving endless strainer belt which allows escape of water. From this belt the paper ribbon is passed to the usual paper processing machinery. -A.H.

96. GRANT, Z.C.

1962. Aquatic weed control program of the Central and Southern Florida Flood Control District. Hyacinth Contr. J. 24-31, figs. 10.

Measures used by the Central and S. Florida Control District for the control of aquatic weeds are briefly reviewed. Water lettuce (Pistia stratiotes) is well controlled by diquat at 2-4# + wetter, while 2,4-D amine at 2-4# is used almost exclusively against water hyacinth (Eichhornia crassipes). Chemical treatment or the use of a dragline have proved either ineffective or uneconomic against coontail (Ceratophyllum demersum), elodea (Elodea canadensis) and southern naiad (Najas guadalupensis) on canal bottoms. An attempt being made to control these species by plowing the canal beds with a heavy-duty plow mounted on an amphibious truck and removing the trash from barriers spaced at intervals downstream shows promise. Alligator weed (Alternanthera philoxeroides) is controlled by a mixture of 2,4-D amine + Aqua-Herb (?) each at 0.5 gal in 50 gal water applied at between 100 and 200 gal per ac. at intervals of 6 weeks. On canal and ditchbanks, maidencane (Panicum hemitomon) and paragrass (P. purpurascens) are controlled with an initial application of dalapon at 8-10#, with a further application 2 to 3 weeks later and thereafter every 3 to 4 months.

Current annual expenditure of the Flood Control District for the control of aquatic weeds is $130,000. -Weed Abstr. 14(6),1965.

97. GREEN, K.R.

1969. Water hyacinth (Eichhornia crassipes). Agric. Gaz. N.S.W., 80(11):628-9. (N.S.W. Dept. Agric., Sydney 2000, Australia)

Water hyacinth is a problem in several rivers and irrigation areas in New South Wales but effective control programmes have been carried out on the Richmond and Hawkesbury Rivers. Recommendations for its control include 0.1 to 0.2% solutions of 2,4-D applied

during vigorous growth at 200 to 400 gal/ac and, where there is a risk of 2,4-D drift damage in neighbouring crops. diquat 20% product at 1 pint/ac + 3 pints wetter per 100 gal. spray and aminotriazole 25% product at 2 to 4 pints/ac each applied in 200 gal solution/ac. -Weed Abstr. 19(5),1970.

98. GRIST, D.H.

1965. Rice. (Weeds in Rice Field). Longmans, London, 4th ed., pp. 548, 75s. (Bibl. 734).

Chapter XII, Weeds, pp. 260-75. Reviews the position regarding major weeds of rice fields including Echinochloa crus-galli and E. stagnina, Cyperus iria and C. dehiscens (Ceylon), Typha spp. (Asia and Western Hemisphere), Heliconia sp. (Guiana and Surinam), Ischaemum rugosum (Thailand and Surinam), Panicum phyllorhyzoide (Italy) and Oryza rufipogon (North and South America). It includes the information in East Pakistan jute (Corchorus sp.) and Sesbania spp. are sometimes cultivated on river banks to exclude Eichhornia crassipes while in North Side algal growth is controlled by $CuSO_4$ at the rate of 16-20#. The second part of the chapter deals with the use of 2, 4-D, 2,4,5-T and MCPA, pre-planting, pre-em. and post-em. in rice fields.

The risk of pesticides to fish, pp. 283-9. This includes a table giving the approximate maximum safe upper limits of concn. of several herbicides. -Weed Abstr. 16(5),1967.

99. GUPTA, O.P.

1968-69. Scope and planning of weed control research in Rajasthan. Prabuddh Krishak, (Rajast. Coll. Agric. Udaipur Mag.), 41-6. (Rajasthan Coll. Agric., Udaipur, India).

In W. and N. Rajasthan, soils are sandy to sandy loam in texture and the rainfall insufficient to support much weed growth; important noxious weeds include Striga lutea, Tribulus terrestris, Alhagi camelorum and Pluchea lanceolata. Pre-flowering application of 2,4-D to S. lutea to control seed production is perhaps the best herbicidal tool available at present. T. terrestris, which often invades natural grass covers, can be controlled with 2,4,5-T at the 2- to 4-leaf stage.

High weed infestation is a problem on medium to heavy soils with adequate moisture in mid-west to southern parts of the state. Application of atrazine at 0.5 kg/ha pre-em. in maize is recommended when a sensitive crop like wheat is to follow; 2,4-D amine 0.75 kg/ha may be applied 40-45 days after sowing the wheat. Diuron at 1 kg/ha pre-em. gives 4-5 weeks, weed control in cotton sown in the rains after which normal inter-row cultivation can be carried out. No work has been done on weed control in leguminous crops. A weed map is needed. Special weed problems of mid-west and southern regions include Orobanche spp., Cynodon dactylon, Cyperus rotundus and Convolvulus arvensis. Eichhornia crassipes is invading pond reservoirs. Sites for weed control stations are suggested as well as legislation making certain weed control measures compulsory for farmers. -Weed Abstr. 19(4),1970.

100. HALL, J. and others

1966. Observations on aquatic weeds in the Volta basin (Ghana). Pap. read at. Int. Symp. Man-Made Lakes, Accra, pp. 2. (Univ. Ghana, Legon).

Potentially dangerous species include Pistia stratiotes, Vossia cuspidata and Scirpus cubensis. Species which have proved troublesome in other parts of Africa, Eichhornia crassipes; Salvinia auriculata and Cyperus papyrus, were absent. -Weed Abstr. 17(5),1968.

101. HAMMOUDA, M.A.

1968. The water outlay by Eichhornia crassipes and observations on the plant chemical control. Phyton, Horn, 13(1/2):97-106, (Bibl. 14; Dept. Bot., Ain Shams Univ., Cairo, United Arab Republic)

The results of evapotranspiration and transpiration studies conducted during 1966 showed that the daily evapotranspiration rate from water surfaces occupied by E. crassipes was 1.3 to 2.6 times greater than that from open water surfaces. Measured evapotranspiration rates from E. crassipes growing in tanks were 2 to 3 times higher than the potential evapotranspiration from a Lippia cover on irrigated land. This considerable water loss was attributed to the fact that the stomata in E. crassipes are continually open. The rate of transpiration throughout the day or the season was correlated with atmospheric evaporating factors. The effect of 2,4-D-amine, paraquat and dalapon at 10 to 1000 ppm concn. on plant growth and transpiration were also studied and indications of change in relative transpiration after treatment with 0.1 l. spray solution/m^2 were considered. 2,4-D-amine gave the most effective control, a concn. of 50 ppm giving complete kill within 11 days. Paraquat was effective at 100 ppm but dalapon was so only at 500 and 1000 ppm. In aquaria experiments 5 ppm of 2,4-D amine gave complete kill of E. crassipes in 10 days. Root elongation was almost completely inhibited by all concns. 0.01 ppm of 2,4-D while shoot growth was slightly stimulated by 0.1 ppm. -Weed Abstr. 19(4),1970.

102. HARI, M.N. and SRINIVASAN, K.M.

1966. Observations on the comparative effectiveness of aminotriazole and 2,4-D amine in the control of water hyacinth (Eichhornia crassipes). Madras Agric. J., 53(7):289-92.

2,4-D amine sprayed at 3 kg a.i./ac killed the aerial parts of E. crassipes in 14 days, but resprouting began 14 days later, and reinfestation was complete after 6 months. Amitrole sprayed at 0.5 kg a.i./ac took 42-60 days to kill the aerial parts, but resprouting had not begun after 6 months. -Field Crop Abstr. 20(2),1967.

103. HATTINGH, E.R.

1960. Survey of certain weed control problems in Africa south of the Sahara. Proc. Brit. Weed Contr. Conf. 1958, 4:215-24, bibl. 23. (African Explosives and Chemical Ind., Ltd., Johannesburg)

The vegetation types found in Africa south of the Sahara are briefly described and the general problems in tropical weed control discussed. Certain major problems are reviewed under the heads: bush control in natural grazing; weed control in maize, chiefly by pre-emergence treatments; control of aquatic weeds, chiefly water hyacinth (Eichhornia crassipes). - Field Crop Abstr. 14,1961.

104. HEARNE, J.S.

1966. The Panama Canal's aquatic weed problem. Hyacinth Contr. J., 5:1-5. (Panama Canal Co., Balboa Heights, Canal Zone, Panama)

An account is given of the programmes carried out by the Dredging Division of the Panama Canal Co. for the mechanical and chemical control of water hyacinth (Eichhornia crassipes), Elodea sp., coontail (Ceratophyllum demersum), Cabomba sp. and various grasses, which have arisen partly as a result of the influx of debris from the Chagres River. Chemicals used for the control of E. crassipes include arsenic + soda sprays up to 1935, copper sulphate solutions up to 1952 and 2,4-D from 1948. Trials in progress or planned include the evaluation of economical alternatives to copper sulphate for the control of Elodea sp., naiad (Najas sp.) and C. demersum, and a small-scale introduction of manatees (Trichechus manatus) for the suppression of E. crassipes. (See also Weed Abstr. 15:527). -Weed Abstr. 16(5),1967.

105. HEINEN, E.T. and AHMED, S.H.

1964. Water hyacinth control on the Nile River, Sudan. Publ. Inf. Proc. Centre, Dept. Agric., Khartoum, p. 56, bibl. 19.

The history and extent of infestation of the Nile by water hyacinth (Eichhornia crassipes) are reviewed, together with the organisation of the control campaign instituted in the Sudan and the techniques used. Water hyacinth was first reported in the Nile in 1958, since when it has infested over 1000 miles of the Nile river system between Juba in the S. to the Jebel Aulia dam in the N., just in front of the confluence of the White Nile and the Blue Nile. The Blue Nile has not so far become infested. The control programme is based on the use of 2,4-D amine at 4#, applied from spray boats, aircraft, mobile trucks and knapsack sprayers. -Weed Abstr. 14(6),1965.

106. HELD, M.W.

1965. Chemical programming in the Texas Gulf Coast drainage areas. Proc. 18th Sth. Weed Control Conf., 365-7. (Houston Spraying & Supply Co., Houston, Texas)

Programmes for the clearance of vegetation in bayous in Texas coastal areas include the use of fenoprop and dalapon for the control of cattail (Typha sp.) and water hyacinth (Eichhornia crassipes), and AMS at 60# in 95 gal water + 5 gal diesel oil for the control of willows (Salix sp.). -Weed Abstr. 15(2),1966.

107. HITCHCOCK, A.E.; ZIMMERMAN, P.W. and others

1949. Water Hyacinth growth, reproduction and practical control by 2,4-D. Boyce Thompson Inst. 15(7):363-401.

The 2,4-D spray treatments and methods of applying them to water hyacinth in Louisiana at all seasons of the year, proved constantially more effective. In field tests in Louisiana the alkanolamine salt of 2,4-D killed and sank 90-100% of the treated water hyacinth during the period May 1948-Feb. 1949. Effective killing occurred when the concentration of 2,4-D was 0.3% or higher, the rate of application 2 lb per acre or more, and the rate of delivery 6-150 gal. per acre. The isopropyl ester of 2,4,5-T proved effective, in preliminary tests, for killing and sinking alligator weed and water hyacinth unless used in excess of 8 lb per acre.

Water hyacinth seedlings grew best under greenhouse conditions in soil saturated with water, and thereafter in water containing some of the nutrients normally present in a good soil. A composted

soil added at the rate of 100-150 gms. per litre of tap water proved satisfactory for the growth of seedlings with the first crop of float leaves and for the growth and production of offshoots on adult plants for a period of two months or longer. -R.K.

108. HITCHCOCK, A.E.; ZIMMERMAN, P.W. and others

1950. Growth and reproduction of water hyacinth and alligator weed and their control by means of 2,4-D. Boyce Thompson Inst., 16 (3):91-130.

Tests carried out in 1948 and 1949 showed the following results: 8 lb per acre dose of 2,4-D was effective throughout the year in causing water hyacinth to sink in 2-3 months. The ester of 2,4-D were of about equal effectiveness to the amine salt.

The rate at which hyacinths sank after treatment with an effective dose of 2,4-D depended upon the age of the plants growing in a given location.

Alligator weed exhibited little or no growth and could not survive for more than 21 months unless its roots were anchored in soil. Effective control of hyacinths and alligator weed depended upon the proper use of spray equipment for a given set of conditions. Sprays delivered by low-pressure equipment (150 lb. p.s.i. or less) were more effective than sprays delivered at pressures above 150 lb. p.s.i. The decreasing order of efficiency for sprayers used in practical control operations was: the helicopter which delivered 2 gal. of spray solution per acre, the TOC 1¼ inch boomjet delivering 75 gal. or less per acre, and the gun-type sprayer delivering 150-200 gal. per acre. -R.K.

109. HOLM, L.

1966. The role of weed control in agricultural development. Proc. 8th Br. Weed Control Conf., 689-701. (Fd. Agric. Org., Rome, Italy)

Aspects discussed include the economic and other losses caused by weeds in arable and non-crop situations (mainly in territories other than Europe and N. America), the present status and potential of chemical weed control and research and extension work on weeds and their control carried out by F.A.O. World distribution maps are included for Cyperus rotundus, Cynodon dactylon and Eichhornia crassipes. -Weed Abstr. 16(5),1967.

110. HOLM, L. and HERBERGER, J.

1969. The world's worst weeds. Proc. 2nd Asian-Pacific Weed Control Interchange, 1-14. (Univ. Wisconsin, Madison).

Of the 200,000 recorded angiosperms, some 30,000 may behave as weeds and 50 of these are of world-wide importance. The 10 most important weeds are considered to be Cyperus rotundus, Cynodon dactylon, Echinochloa crus-galli, E. colonum, Eleusine indica, Sorghum halepense, Eichhornia crassipes, Imperata cylindrica, Lantana camara and Panicum maximum; world distribution maps of each weed are given together with their distribution in the major rice and sugar-cane regions of the world and that of Cyperus spp. in major crops. Weeds peculiar to rice and sugar-cane fields are listed separately for south-east Asia and for the world. -Weed Abstr. 20(2),1971.

111. HOLM, L.G.
1967. The role of weed control in agricultural development. PANS: Sect. C., Weed Control, 13(2):90-103.
In this address to the 8th British Weed Control Conference, weed control problems are outlined in the context of assistance to developing countries by FAO. Subjects discussed include: (1) the serious problems posed by bush encroachment of tropical pastures and by weed invasion of inland waters, and progress made with their herbicidal control; (2) the enormous economic importance of a limited number of weeds that through human activity now have a world-wide distribution, in particular Cyperus rotundus, Cynodon dactylon, Echinochloa crus-galli, and Eichhornia crassipes; (3) present use of herbicides in the various parts of the world. It is stressed that considerable crop yield increases in developing countries will only be possible if the use of herbicides becomes the common practice. Maps. -Trop. Abstr. 22(10),1967.

112. HOLM, L.G. and others
1969. Aquatic weeds. Science, N.Y., 166(3906):699-709. (Bibl. 29; Coll. Agric., Univ. Wisconsin, Madison).
Eichhornia crassipes, Salvinia spp., Pistia stratiotes, submerged and emersed weeds, phreatophytes, floating island weeds and chemical, biological and mechanical control are the subjects reviewed. -Weed Abstr. 19(5),1970.

113. HOLM, L.G. and others
1970. Aquatic weeds. PANS, 16(4):576-89.
Aquatic weeds obstruct water flow, increase evaporation, cause large losses of water by transpiration, and prevent proper drainage of land. Detailed attention is paid to the free-floating weeds, water hyacinth (Eichhornia crassipes), water fern (Salvinia auriculata), and water lettuce (Pistia stratiotis). Serious submerged weeds are: Elodea canadensis, Myriophyllum spicatum, Potamogeton spp., Egeria spp., Najas spp., Ceratophyllum spp., Ranunculus spp., Vallisneria spp., Utricularia spp., Cabomba spp., and Hydrilla spp. Emerged weeds have their roots below the water surface and their stems and leaves above the surface; Scirpus and Typha spp. belong to the emerged weeds. In addition, attention is paid to chemical, biological, and mechanical control. Photos. Map. 29 refs. -Trop. Abstr. 26(10),1971.

114. INTERNATIONAL ADVISORY COMMITTEE FOR BIOLOGICAL CONTROL
1965. Biol. Control Inf. Bull., no. 1, p. 40.
Australia. Biological control projects include: for Xanthium pungens in Queensland introduced stem borers (Mecas saturnia from U.S.A. and Nupserha antennata from India); for Lantana camara in Queensland introduced lepidopterous defoliators (Catabena esula, Syngamia haemorrhoidalis and Diastema tigris), for Senecio jacobaea the introduced lepidopterous defoliator Tyria jacobaeae.
Canada. Biological control projects include: for Linaria vulgaris and L. dalmatica introduction of Calophasia lunula; for Cirsium arvense and C. vulgare establishment of Altica carduorum being followed with other introductions planned; for Centaurea spp., Rhamnus cathartica, survey in Europe. For Berberis vulgaris a survey is planned. For Euphorbia cyparissias and E. esula projected

introduction of Celerio euphorbiae; for Hypericum perforatum attempted establishment of Agrilus hyperici; for S. jacobaea establishment of Tyria (Hypocrita jacobaea being followed; for Convolvulus spp. insects being surveyed around Belleville.

Commonwealth Institute of Biological Control, Delemont, Switzerland. Biological control projects include; for Rhamnus cathartica survey of phytophagous insects and their host specificity; for Euphorbia esula life history and host specificity of Chamaesphecia empiformis; for Centaurea spp. observations on phytophagous insects; for Cirsium and Carduus spp. survey of phytophagous insects partially completed; for Rosa rubiginosa survey of phytophagous insects. Also being studied are the life history of Diplolepis rosae and its introduction into New Zealand and the life history of promising insects feeding on Ulex europaeus.

C.I.B.C., Bangalore, India. Projects include: for Striga spp., Cyperus rotundus, Eichhornia crassipes and other aquatic weeds survey for natural enemies, including pathogenic micro-organisms of the weeds in India with a view to their possible utilization in biological control in U.S.A. and for Eupatorium glandulosum in India introduction of Procecidochares utilis. P. utilis is established on E. glandulosum in Darjeeling (West Bengal) and gradually spreading.

C.I.B.C., Rawalpindi, Pakistan, Projects include a survey for natural enemies of Halogeton sp., Cyperus sp., Striga sp., Carduus sp., Cuscuta sp. and Xanthium sp.

C.I.B.C., Kampala, Uganda. Projects include: for L. camara control in Kenya and Uganda using imported enemies; for Striga spp. survey of enemies and investigation of possibilities of control in E. Lake Region, Tanzania; for Cyperus aromaticus in Fiji survey of its enemies and of those of related species.

C.I.B.C., Curepe, Trinidad. For Salvinia auriculata preliminary feeding tests have been undertaken at Belem, Brazil, with Paulinia acuminata, Cyrtobagous singularis and Samea multiplicatis. On the basis of these tests their introduction for control in the Kariba Lake will be recommended.

New Zealand. For H. perforatum leaf feeding beetles and gall midges have been introduced from Australia and became established; for Eupatorium adenophorum further dispersal of gall insects introduced from Australia in 1958 is being undertaken. Control of this weed by P. utilis appears to be on the way to success.

South Africa. Projects include: for H. perforatum introduction and attempted establishment of Chrysolina spp. in Western Cape Province; for L. camara introduction and attempted establishment of insect enemies in Natal.

U.S.A., Berkeley, California. For Tribulus terrestris control by the weevils, Microlarinus lareynii and M. lypriformis is being attempted. Insects are being used to control Sarothamnus scoparius, S. jacobaea, U. europaeus, Salvia aethiopis, Cardaria draba, Centaurea repens, H. perforatum and Orobanche sp. Successful biological control of H. perforatum has been obtained.

Riverside, California. Projects include the biological control of nut-grass (Cyperus rotundus), Spanish broom (Cytisus sp.), prickly pear (Opuntia sp.) and certain thistles and nettles. Microlarinus lareynii and M. lypriformis from Italy have been released against T. terrestris.

U.S. Biological Control, Rome, Italy. The insect enemies of the following are being investigated; Cytisus scoparius (Sarothamnus scoparius), Salvia aethiopis, Halogeton glomeratus, Linaria dalmatica, S. jacobaea and thistles. Heterographus fulvobasella was sent to California to test against H. glomeratus. Apion fuscirostre was successfully introduced (into the U.S.) against C. scoparius.

U.S. Biological Control, Buenos Aires, Argentina. A flea beetle, Agasides sp. has been tested and released in the U.S. against Alternanthera philoxeroides.

Hawaii. A survey of natural enemies of Eupatorium riparium is being undertaken in Mexico and other American countries. T. terrestris and T. cistoides are very effectively controlled by Microlarinus lypriformis and M. lareynii (up to 99% mortality). -Weed Abstr. 15(5/6),1966.

115. KAMAL, I.A. and LITTLE, E.C.S.
1970. The potential utilization of water hyacinth for horticulture in the Sudan. PANS, 16(3):488-96. (Bibl. 7; Amer. Univ. Beirut, Republic of Lebanon)

In the Sudan, desiccation of Eichhornia crassipes for 2-3 days in the sun reduced the weight to ¼ of the fresh weight. E. crassipes can be used as a mulch to provide needed o.m. for soils near the Nile; 125 tons d.m./feddan (= 1.04 ac) are required for good weed control. Good compost can be made from E. crassipes but further research is needed: burning could produce ash with fertilizer value. -Weed Abstr. 20,1971.

116. KAPOOR, V.P. and JOSHI, N.C.
1965. Some trials with newer weedicides for the control of water hyacinth. Pl. Prot. Bull., New Delhi, 17(1/2):16-18. (Bibl. 11)

The results are given of herbicide evaluation trials on the control of Eichhornia crassipes at Kanpur in summer 1963 and Ghaziabad in winter 1964. All compounds were applied at 1.5 and 2# in 120 gal spray. No appreciable differences were evident between the results at either location. On assessment 40 days after treatment, 50 to 60% of the infestation treated with the higher rate of aminotriazole sank without appreciable regeneration while on plots treated with diquat only 15% of the infestation sank. Both the sodium and amine salts of 2,4-D resulted in 70 to 80% desiccation but only the latter formulation resulted in a satisfactory level of submergence (up to 75%). -Weed Abstr. 17(6),1968.

117. KARIM, ALI
1945. Manufacture of molded products from vegetable starting Material. United States Patent 2,382,568.

The patented invention involves the conversion of water hyacinth (Eichhornia crassipes) to a plastic moulding material without any addition of binding material.

The fresh or dried plant is boiled in water with or without alkali (sodium or potassium hydroxide, carbonate of lime, burnt water hyacinth ash) until it is reduced to a soft pulp. The pulp is washed, to remove dirt and alkalinity, and stored under normal atmospheric conditions to allow fermentation to take place (3 to 7 days). The

slimy fermented pulp is able to bind considerable amounts of water and can be molded in this swollen state. On drying the molded shape is retained. Such binding properties are due to the presence of nitrogenous and inorganic constituents which comprise 25% of the dry weight of the plant.

Before molding, the fermented water hyacinth pulp can be mixed with other fermented vegetable pulps. Mixing with jute stalk pulp (left after jute fibers have been retted out) facilitates drying of the mold: however the water hyacinth fraction is the major contributor to toughness and compactness. Molding and drying are conducted under a suitable combination of heat, pressure and suction.

When dry, the molded product can be finished by sandpapering and coated with varnish or paint. Products are suitable for furniture, electric insulation boards, radio cabinets, etc. -A.H.

118. KARIM, ALI

1948. Microbiological decomposition of water hyacinth. Soil Sci., 66:401-16.

Water Hyacinth (Eichhornia crassipes) is a serious pest in Bengal. Its decomposition in compost and soils was studied with a view to its use as a nitrogen manure. Preliminary flask experiments tested breakdown of different constituents with inoculum from well-rotted manure under aerobic and anaerobic conditions with addition of $(NH_4)_2SO_4$ alone or + $CaCO_3$, NH_4NO_3 or $NaNO_3$. Profuse and no fungal growth occurred under aerobic and anaerobic conditions respectively. Under aerobic conditions, more than 50% of the dry matter disappeared in 50 days, decomposition being most rapid in the first 15. Addition of nitrogen slightly accelerated the process in an increasing order; $(NH_4)_2SO_4$, NH_4NO_3, $NaNO_3$. Non-nitrogenous constituents disappeared more rapidly than nitrogenous. Water hyacinth manure compared favourably in efficiency with horse manure.

In similar experiments mixing powdered hyacinth with 2 soils, Dacca pH 5.4 and Faridpur pH 8.35, samples were analysed for total, ammoniacal and nitrate nitrogen every 15 days. Part of the nitrogen in the weed becomes readily available in the soil, stem nitrogen being more available than leaf nitrogen. High levels of ammonia accumulated in soils after addition of water hyacinth but did not undergo nitrification for 45 days. Levels of ammonia were higher in Dacca than in Faridpur soils. Analysis of soil microbial flora showed that Dacca soils have a higher fungal population and Faridpur soils a higher bacterial population. Both these populations increased in the presence of water hyacinth but that of Azotobacter decreased. It appears that decomposition of E. crassipes is mainly due to fungi. -A.H.

119. KRISHNAPPA, D.G.

1971. Cytological studies in some aquatic angiosperms. Proc. Indian Acad. Sci. Sect.B 73(4):179-185.

Hydrolea zeylanica Vahl (2n = 24), Ipomoea aquatica Forsk. (2n = 30, 2n = 30 + 1), Ottelia alismoides Pers. (2n = 22 and 33), Monochoria vaginalis Presl ex Kunth (2n = 52), Eichhornia crassipes Solms (2n = 32), Pistia stratiotes L. (2n = 28), Limnophyton obtusifolium Miq. (2n = 22) and Ammannia salicifolia Monti (2n = 28) were collected from the suburbs of Mysore. The chromosome numbers for Hydrolea zeylanica and Ammannia salicifolia are new reports.

Karyomorphological studies were made in H. zeylanica, A. salicifolia, I. aquatica, O. alismoides, L. crassipes and L. obtusifolium. Mitotic studies of O. alismoides reveal the occurrence of both diploid and triploid races. Of these, triploid number of 2n = 33 is the 1st report. An unusually small chromosome from somatic nuclei is also the 1st record in I. aquatica. O. alismoides had univalents, tetravalents and hexavalents, while L. obtusifolium had chromatin bridges, fragments and micronuclei. -Biol. Abstr. 52(22),1971.

120. LAHSER, C.W.

1967. Tilapia mossambica as a fish for aquatic weed control. Progve. Fish Cult., 29(1):48-50. (Bibl. 10; Sinton, Texas 78387)

Four tilapia (Tilapia mossambica) 3-5 in. long were placed in 10-gal aquaria with a water temperature of 60-70°F after starving for 48 h. A series of feeding experiments was made with Chlorophyta, Cyanophyta, Chrysophyta, Bryophyta, Pteridophyta and Spermatophyta. Rooted plants were weighed to prevent floating. With the exception of Lemna minor and Azolla caroliniana, plant populations were representative of the areas where T. mossambica is established. The plant/fish associations were maintained for 48 h. As equal weights of plant species were placed in the tanks, relative preference was determined by noting the amounts of each species remaining after the test period.

T. mossambica showed a preference for periphyton which they scraped from rocks and sides of the aquaria. Close observation of feeding fish indicated that the consumption of many vascular plants was incidental to the removal of periphyton using the plants as a substrate. The fish showed definite preferences among the plant species offered although there were no big differences in the periphyton on individual species. L. minor and A. caroliniana were consumed first in all tests. At the other extreme Elodea densa and Riccia crystata were not eaten even when they were alone. Cabomba caroliniana, Myriophyllum brasiliense, Potamogeton crispus, Vallisneria americana and Najas guadalupensis were eaten extensively. Eichhornia crassipes, Jussiaea repens, Brasenia schreberi and Ludwigia natans were killed through the destruction of roots and stems but were not consumed in appreciable amounts. Casual observations in the field indicate that the fish will eliminate aquatic vegetation (including Najas, Heteranthera and Chara spp.) and marginal vegetation (including Zizania, Setaria, Paspalum, Echinochloa, Cyperus and Polygonum spp.) from the bottom and margins of rearing ponds. -Weed Abstr. 18(6),1969.

121. LAPHAM, L.H.

1964. Can the manatee save Florida? Sat. Even. Post., 237 (25):38-9.

The potentialities of manatees (Trichechus manatus) for controlling water hyacinth (Eichhornia crassipes) in Florida are discussed. -Weed Abstr. 15(2),1966.

122. LAPHAM, V.T.

1966. Control of alligator weed with picloram. Proc. 19th Sth. Weed Conf., 409-13. (Bibl. 19; Louisiana Wildl. Fish. Commn., Baton Rouge).

Two applications of Tordon 22K (picloram 24.9%) at 5 lb (product?)/ac gave complete control of alligator weed (Alternanthera philoxeroides) for 2 years though excellent control was also obtained with rates down to 0.5# followed by a further application when regrowth was 4-5 in. high. The action of picloram was enhanced by the addition of X-77 (alkylaryl polythoxy ethanol + free and combined organic and inorganic fatty and phosphatic acids) at 1-2 pints/ac. A floating mat of A. philoxeroides was almost eradicated by Tordon 10K at 3 lb a.e./ac applied with a power-blower in early April, but was less susceptible to the same formulation applied in July or to similar rates of a 2% granular formulation. Neither liquid nor granular formulation of Tordon were effective against Eichhornia crassipes, but mixed stands of E. crassipes and A. philoxeroides were well controlled by Tordon 101 (tri-isopropanolamine salts of 2,4-D 39.6% + picloram 10.2%) at 1 gal/ac. -Weed Abstr. 16(6),1967.

123. LAPHAM, V.T. and LEE, D.V.
1967. The lignin sulfonates-promising new adjuvants. Proc. 20th Sth. Weed Conf., 334-5. (Louisiana Wildl. and Fish. Commn., Baton Rouge).

Lignosulphonates appear to be effective as dispersants or wetters in reducing minimum effective rates of herbicide in aquatic and dry land situations. In one test using ammonium lignin sulphonate, Eichhornia crassipes was killed and Alternanthera philoxeroides severely injured by a surface application of 2,4-D dimethylamine 0.25 gal/ac + 1 gal/ac of a solution containing 2 lb lignin sulphonate/gal in 200 gal water, while more complete control of A. philoxeroides was achieved with 2,4-D 1 gal/ac + lignin sulphonate 2 gal/ac also in 200 gal/water. Excellent plant response was obtained on dry land by combining 1 gal lignin sulphonate/ac with normally recommended rates of herbicide in 200 gal water/ac. -Weed Abstr. 18(2),1969.

124. LAWRENCE, J.M.
1966. Effects of soil applied trifluralin on fish production in pools. Abstr. Meet. Weed Soc. Am., 89-90. (Alabama Agric. Exp. Stn., Auburn).

Trifluralin at 6 rates was incorporated in the soil at the bottom of plastic pools 7 days before flooding. Each pond was stocked with 20 fathead minnows (Pimephales promelas) immediately after flooding on 27 April 1965, and with water hyacinth (Eichhornia crassipes), parrot-feather (Myriophyllum brasiliense), southern naiad (Najas guadalupensis), waterthread pondweed (Potamogeton diversifolius) and alligator weed (Alternanthera philoxeroides) within the week following flooding. No mortality occurred among fish during the 4 weeks after flooding. Fish in all ponds reproduced and after six months average fish productions of 43, 32, 40.2, 27.5, 24.3 and 42.7# were obtained from trifluralin treatments at 0.5, 1, 2, 4, 8 and 16# respectively as compared to fish production of 12# in the untreated pools. The 5 plant species showed no symptom of herbicidal activity but did not increase in size as much as those in the control ponds. -Weed Abstr. 16(6),1967.

125. LAWRENCE, J.M., BLACKBURN, R.D. and BEASLEY, P.G.
1961. Aquatic herbicide evaluation tests using plastic pools. Proc. 14th Southern Weed Conf. 1961, 309-16, tabs. 2. (Alabama Agric. Exp. Sta., Auburn)

For two evaluation trials, vinyl plastic pools 9 ft in diam. and 30 in. deep were planted with Najas guadalupensis, Potamogeton diversifolius, Elodea densa, Alternanthera philoxeroides, Eichhornia crassipes, Lemna minor, Heteranthera dubia and Pithophora sp. and stocked with fathead minnows and (in the second trial only) sunfish. In the first trial in which 2,4-D and fenoprop dissolved in (a) ethanol and (b) acetone were compared at 5 ppm., there was little difference between the two compounds. After 9 months both had eliminated N. guadalupensis, E. crassipes and L. minor; P. diversifolius and H. dubia were also eliminated by fenoprop, and were severely checked in growth by 2,4-D. In the second trial, diquat dibromide alone at 2 ppm. and at 1 ppm. + MCPA 3 ppm. was much the most effective herbicide and had eliminated all species except Pithophora sp. and A. philoxeroides (which was heavily damaged) within 2 months. Next in effectiveness was sodium arsenite 4 ppm., followed by endothal 2 ppm., amitrole 1.5 ppm. + MCPA 3 ppm., and, lastly, copper sulphate 1 ppm. Detailed results are given of the effects of these compounds on the individual spp. There were no deaths of fish in either trial. -Weed Abstr. 11(2),1962.

126. LEIDERMAN, L. and FIGUEIREDO, P.
1967. Eradication of Eichhornia azurea in the Ribeira River by application of herbicides. Biologico, Brasil, 33(6):121-5.

Dense growths of Eichhornia azurea in a river of the State of São Paulo (Brazil) were sprayed with 6 herbicides at various rates. Complete control of the weed was obtained with paraquat applied at a rate of no less than 2.5 kg active ingredient per ha, and with the smallest dosages tested of the 5 other formulations, viz. (in acid equivalent). 1.25 kg picloram, 0.8 kg picloram + 2 kg 2,4-D, 4 kg 2,4-D, 4.24 kg fenoprop, and 4.5 kg 2,4,5-T per ha. The maximum effect was obtained after 3 weeks with paraquat and picloram, after 4 weeks with fenoprop, after 5 weeks with the picloram/2,4-D mixture, after 6 weeks with 2,4-D and 2,4,5-T. English summary. Table. 4 refs. -Trop. Abstr. 22(12),1967.

127. LEIDERMAN, L. and GRASSI, N.
1970. Chemical control of water hyacinth in the Rio Preto, Peruibe, São Paulo. Biologico, Brasil, 36(6):157-9.

A trial was carried out on the chemical control of water hyacinth, Eichhornia crassipes, in the Rio Preto (State of São Paulo, Brazil). Full control was achieved by applying diquat at a rate of 2.5 l/ha, and 2,4-D (amine) at a rate of 10 l/ha. This effect was reached after 3 weeks with diquat and after 5 weeks with 2,4-D (amine). The results of the applications of paraquat and Tordon-101 were much less satisfactory. Table. 2 refs. -Trop. Abstr. 26(5),1971.

128. LEIDERMAN, L. and GRASSI, N.
1971. Chemical control of the aquatic plant aguape (water hyacinth) in the Rio Preto, municipality of Peruibe, São Paulo, Biologico (São Paulo), 36(6):157-159.

Four different herbicides were applied to the leaves of the aguape (Eichhornia crassipes Mart. Solms): Gramoxone (paraquat), Reglone (Diquat), Formula 40(2,4-D amine) and Tordon 101 (picolinic acid plus 2,4-D). Best results were achieved with Reglone at the rate of 2.5 l/ha, and Formula-40 at 10 l/ha. -Biol. Abstr. 52 (18),1971.

129. LITTLE, E.C.S.

1965. The world wide distribution of the water hyacinth. Hyacinth Contr. J., 4:30-2, bibl. 2.

The capacity of the water hyacinth to cover large tracts of water throughout many tropical and sub-tropical countries is discussed together with the wide variation in its growth and development in different places under apparently similar conditions. As the recommended treatment with 2,4-D at 4 # is too costly for large scale use in many countries the possible use of biological control methods is discussed and it is suggested that water hyacinth should be investigated as a potential source of animal food or industrial raw material. -Weed Abstr. 15(5/6),1966.

130. LITTLE, E.C.S.

1967. Progress report on transpiration of some tropical water weeds. PANS; Sect. C., Weed Control 13(2):127-32.

Greenhouse trials conducted in England indicated that aquatic weeds may considerably increase water losses from inland waters by their transpiration. Well-grown plants of Eichhornia crassipes with leaves 30-40 cm. long increased the water loss-4-to 5-fold, and a higher ratio may be expected in the tropics. Relatively small plants of Pistia stratiotes increased evaporation losses 2 to 3 times. Salvinia auriculata under relatively still air conditions did not increase water losses, probably because of the dense layer of hairs on the surface of the leaves; however, in moving air it may contribute appreciably to water loss. Graphs. 1 ref. -Trop. Abstr. 22 (10),1967.

131. LITTLE, E.C.S.

1967. Some weed problems of South America. PANS (C), 13(4): 291-7. (A.R.C. Weed Res. Org., Kidlington, Oxford, England)

Problem weeds described include a giant form of water hyacinth (Eichhornia crassipes) found at Porto Alegre, Brazil and Solanum glaucum, a plant poisonous to cattle in the Buenos Aires region of Argentina (see Weed Abstr. 16:1763). In Argentina Stipa brachychaeta, a serious invader of lucerne, is controlled by competition from Festuca alba, Dactylis glomerata and Phalaris tuberosa. The cattle prefer these grasses to lucerne which gives it a chance to smother the S. brachychaeta. Stiba sp. is also a problem in Bolivia. In Chile, onion grass (Arrhenatherum elatius), an important weed of rape, has been controlled by aerial applications of dalapon at 8 kg/ ha. Introduced kikuyu grass (Pennisetum clandestinum) is rapidly invading pastures in Equador. -Weed Abstr. 17(3),1968.

132. LITTLE, E.C.S. (ed.)

1968. Handbook of utilization of aquatic plants. Publ. Food and Agriculture Organization of the United Nations, PL:CP/20, 123 p. (cyclostyled). (Consultant (Weed control), FAO, Rome)

A compilation of selected extracts from published literature from 1918 to the present day. The first section, some 74 pp., deals with one species only, the water hyacinth (Eichhornia crassipes) considered under: (1) Composts, mulches, fertilizer (2) Animal fodder and (3) Protein and other products. The second section, some 23 pp., considers the uses of other aquatic plants, including that

of alligator weed (Alternanthera philoxeroides) as a cattle feed, the water fern (Salvinia auriculata) as manure, and the cultivation of the water chestnut (Trapa natans) in India. -Weed Abstr. 18(2),1969.

133. LITTLE, E.C.S.

1969. The floating islands of Rawa Pening. PANS, 15(2):146-53. (Bibl. 4; UNDP/FAO Range Management Project, P.O. Box 30362, Nairobi, Kenya).

Lumps of peat, forced to the surface by bubbles of gas, have been colonised and made buoyant by Eichhornia crassipes to form floating islands in Rawa Pening, a 2000-ha man-made lake sited on a former swamp in Jawa. Traditional control measures include carving up islands and poling them to sluices en route to the sea. In 1968, the FAO Fisheries Department joined in the struggle. Spraying with 2,4-D amine is effective. The possibility of utilising the islands' vegetation for fodder, fertilizer and fuel is considered. Echinochloa stagnina is highly nutritious to stock and domestic ducks feed on the seed heads. -Weed Abstr. 19(1),1970.

134. LITTLE, E.C.S.

1969. The water hyacinth beautiful but a menace. East African Standard, (16992), 6.

The dangers of introducing the water hyacinth (Eichhornia crassipes) into Kenya are explained. -Weed Abstr. 18(4),1969.

135. LITTLE, E.C.S. and HENSON, I.E.

1967. The water content of some important tropical water weeds. PANS(C), 13(3):223-7. (Bibl. 5; A.R.C. Weed Res. Org., Kidlington, Oxford, England)

In experiments to determine the forage potential of water weeds, fresh weights of Eichhornia crassipes, Salvinia auriculata and Pistia stratiotes were determined after removal of superficial moisture, and dry weights after drying for 48 h. at 80°C. The d.m. content of the plants averaged about 8%, which compares with 8% for Elodea sp., 15% for lucerne and 8.5% for turnips. The crude protein content of E. crassipes has been determined elsewhere as 0.85% of the fresh weight, which compared with 1.57% for Panicum purpurascens, 0.63% for S. auriculata, 0.56% for Elodea sp., 1% for turnips and 3.8% for lucerne. It is suggested that the lower nutritive content of water weeds might be offset by their relative ease of growing, harvesting and sun-drying. -Weed Abstr. 17(2),1968.

136. MADDOX, D.M. and ANDRES, L.A.

1969. Search for South American insects to control aquatic weeds. Abstr. Meet. Weed Sci. Soc., 1969, 50. (Entomology Res. Div., USDA, Albany, California)

Northern Argentina and southern Brazil are considered ideal for the study of potential plant-feeding insects to control aquatic weeds because of the area's floral and climatic similarities to the south eastern United States. Three species have been studied in Argentina for the control of alligator weed (Alternanthera philoxeroides). Over 30 species of insects have been found attacking water hyacinth (Eichhornia crassipes). Insects have also been collected from water lettuce (Pistia stratiotes) and water primrose (Jussiaea spp.).

All promising South American insects are tested for host specificity to assure safety of introduction and specificity of action in the United States. -Weed Abstr. 19(4),1970.

137. MAHENDRANATHAN, T.

1970. Water hyacinth has value as a pig feed. Pig Farmer, 599-607. (Bibl. 11; Pig Breeding and Res. Stn., Serdang, Malaysia).

The practice of feeding water hyacinth (Eichhornia crassipes) to pigs is widespread in Malaysia. Many farmers have special tanks in which the plants are grown, sometimes combining this with fish culture. Drainage from the pig pens is fed into the tanks. Figures from other sources of plant productivity and food value of E. crassipes are given and of liveweight gains of pigs fed on it. Plants are fed chopped fresh after root removal, sliced and boiled in a mash with other ingredients or after being made into silage. - Weed Abstr. 20(5),1971.

138. MALLORY, T.E. and others.

1970. Sequence and pattern of lateral root formation in five selected species. Am. J. Bot., 57(7):800-9. (Bibl. 16; Dept. Bot., Univ. California, Davis).

The proximal-distal distribution of the lateral roots of five species, including Eichhornia crassipes was studied. The laterals of E. crassipes were found to be arranged in groups along the main axis with some degree of regularity. Factors controlling the spacing of lateral root primordia included their relationship with the developing vascular system, a direct effect of the parent root apex, and an effect of older lateral root primordia in the same sector of the root. -Weed Abstr. 20(2),1971.

139. MATTHEWS, L.J.

1967. Seedling establishment of water hyacinth. PANS(C), 13 (1):7-8. (Res. Div. N.Z., Dept. Agric., Hamilton)

One plant may produce 5 to 6 thousand seeds per season; these remain viable for up to 15 years and require a dry period (usually from January to March for germination. -Weed Abstr. 17(3),1968.

140. MATTHEWS, L.J. and MANSON, B.E.

1969. These weeds mean trouble. N.Z. J. Agric., 118(4):33-39.

The increase of aquatic weeds in New Zealand may be attributed to the introduction of new species, the formation of artificial lakes, irrigation canals and stock watering ponds, more extensive use of water for recreational purposes and pollution of waterways with sewage. The distribution and vegetative spread of Ceratophyllum demersum, Lagarosiphon major, Elodea canadensis, Egeria densa, Potamogeton crispus, Aponogeton distachyus, Myriophyllum robustrum, Alternanthera philoxeroides, Glyceria maxima, Paspalum distichum, Zizania aquatica, Eichhornia crassipes, and Azolla rubra, which represent some of the more important and widespread weeds, is discussed, and recommendations for their chemical control are suggested. No suitable control measures are at present known for water primrose (Ludwigia peploides var. montevidensis). See also Weed Abstr. 18:276. -Weed Abstr. 19(1), 1970.

141. MCLANE, W.M.

1969. The aquatic plant business in relation to infestations of exotic aquatic plants in Florida waters. Hyacinth Control J., 8 (1):48-9. (Florida Aquatic Nurseries, Fort Lauderdale)

Regulations governing the importation into the USA of aquatic plants and their inter-State movement are urged in order to curb the establishment of potential weed species. In Florida, species already introduced into natural waters include Hydrilla verticillata, Egeria densa, Elodea canadensis, Myriophyllum spicatum, M. brazilliense, Hygrophila sp., Ambulia sp., A. sessiliflora, Alternanthera philoxeroides, Eichhornia crassipes and Nymphaea sp. Of these all except Hygrophila and Ambulia have become dominant. -Weed Abstr. 19(6),1970.

142. MICHAEL, R.G.

1968. Fluctuations in the relative abundance of the weed fauna of a tropical freshwater fish pond. Hydrobiologia 31(1):37-59. Illus.

A study over a 2-year period of the macroinvertebrates associated with Eichhornia crassipes was made. Two species of Oligochaete are recorded and were most abundant between Jan. and Mar. Five Crustaceans are recorded as well as 8 species of insect (in addition to the immature forms of a number of genera which were not identified to species). Water mites and 4 species of Gastropoda also occurred. Organisms measured as both individuals and volume per 1000 cc of water weed are taken to compare the fauna at different times of the year. Maximum numbers and volume of fauna is recorded in Jan. or Feb. and it is suggested that this is correlated with the maximum growth of algae on the submerged roots of the water weed which also occurs at this time. -Biol. Abstr. 49,1968.

143. MILLER, T.W.

1964. Hyacinth control in Lee County, Florida. Hyacinth Contr. J. (4):20-1.

A progress report on the programme for the control of water hyacinth (Eichhornia crassipes) administered by the Lee County Hyacinth Control District. See also Weed Abstr. 15:343. -Weed Abstr. 15(2),1966.

144. MINER, J.R., WOOTEN, J.W. and DODD, J.D.

1970. Water hyacinths to further treat anaerobic lagoon effluent. Proc. of the Internat. Symp. on Livestock Wastes 1970, 170-73.

It is technically feasible to use water hyacinths for renovating anaerobic lagoon effluent. The effluent was free of color and sufficiently lowered in organic matter and nutrients to allow discharge into many receiving streams. Where it is desired to dispose of lagoon effluent by application to cropland, reduction of nitrogen concentration by using water hyacinths will allow more intense application without danger of groundwater pollution by excess nitrogen. -Author

145. MISRA, G. and DAS, N.

1969. Studies on the control of water hyacinth. I. Response of water hyacinth to two hormone herbicides, 2,4-D and 2,4,5-T. Hyacinth Control J., 8(1):22-3. (Bibl. 10; Dept. Bot., Ravenshaw Coll., Cuttack 3, India)

In pot culture experiments the susceptibility of water hyacinth (Eichhornia crassipes) to sodium salt formulations of 2,4,5-T and 2,4-D increased with increasing age of the plants and with increasing frequency of treatment and was more pronounced where spraying was

carried out in April than in October. Single applications of 2,4, 5-T and 2,4-D at 1000 ppmw killed E. crassipes within 15 and 30 days respectively. Similar patterns of response were evident in an evaluation of the two herbicides in ponds. -Weed Abstr. 19(5),1970.

146. MOLLENHAUER, H.H.

1967. A comparison of root cap cells of epiphytic, terrestrial and aquatic plants. Amer. J. Bot. 54(10):1249-1259. Illus.

Outer cells from the root cap of Cattleya orchids are characterized by their secretory activity. They are arranged in layers intercalated with layers of secretory product and form a protective mantle over the root tip. The ultrastructure of these cells is similar to those of terrestrial roots (for example Zea mays) in that they are characterized by copious quantities of endoplasmic reticulum and numerous dense-staining prevacuolar bodies. In contrast, most root cap cells of water hyacinth and duckweed are highly vacuolate with no dense-straining prevacuolar bodies. The endoplasmic reticulum is sparse and dictyosomes are small and without secretory activity. -Biol. Abstr. 49,1968.

147. MUKHERJEE, R.K. and others

1964. Presence of bound auxin in the roots of water hyacinth (Eichhornia crassipes). In: Botanical Society of Bengal: Symposium on frontiers of plant science, Calcutta, India, 29-30 March, 1964. Bull. Bot. Soc. Bengal 18(1/2):87-90. Illus. 1964. -Biol. Abstr. 48,1967.

148. MULLER, J.R. and STOVELL, F.R.

1966. Development of the bifluid system. Proc. 3rd Int. Agric. Aviat. Congr., Arnhem, 55-9. (E, f; Shell Int. Chem. Co. Ltd. London, England)

The spraying of high viscosity water-in-oil emulsions is described in Weed Abstr. 12:601. Field trials have been shown that invert emulsions of 2,4-D and 2,4,5-T give less initial defoliation but more lasting control of brush than conventional formulations and are much less subject to drift. In trials in the U.K. and Italy in 1964 and 1965, an invert emulsion of dalapon-sodium, applied from an aircraft at 12-14 kg a.e. in 100 l. spray/ha gave 95% control of Phragmites communis. In the U.S.A. and the Sudan, aerial application of 2,4-D at 1-2 kg a.e. in 50-150 l. spray/ha compared favourably, as regards control of Eichhornia crassipes, with 3-4 kg/ha of conventional materials. For aquatic weed control, invert emulsions possess a unique advantage in that spray droplets not impacting directly on foliage float on the surface of water and adhere to emerging foliage; aqueous sprays are diluted and dispersed in water. In the U.K. in 1964/65, 2000 ha of wheat and barley were sprayed aerially on a semi-commercial basis using the bi-fluid system. 2,4-D and MCPA at 0.25-0.5 kg a.e. in 20-30 l. spray/ha compared satisfactorily with rates of 0.6-1.5 kg/ha for conventional materials and gave much better drift control. Spraying was possible in winds up to 20 mile/h and the costs were comparable with the aerial application of conventional materials. -Weed Abstr. 17(5),1968.

149. MYERS, F. and others

1964. Hyacinth control section. 10th Biennial Rep. Louisiana Wild Life & Fish Comm. 1962-63, 1964, 61-7.

A report is given of the activities of the Louisiana State water hyacinth control programme. The severe drought during the last 2 years exposed mud banks on most lakes, permitting the germination of large amounts of water hyacinth seed. From work carried out in the 1940's by N. Gowanlock, it was concluded that seed of E. crassipes can be dormant for up to 20 years and that one plant could multiply to 65,000 in a normal spring/summer season in mid-Louisiana and to much higher numbers in the warmer, S. parts of the State.

Water hyacinth has been relegated to the status of requiring only maintenance patrols for control in Louisiana, though it is now considered unlikely that complete eradication will be achieved. The elimination of water hyacinth has resulted in a great increase in submersed aquatic weeds, the most important of which are coontail (Ceratophyllum demersum), water-milfoils (Myriophyllum spp.) elodea (Elodes densa), fanwort (Cabomba caroliniana) and the pondweeds (Potamogeton spp.). Against these, diquat and mixtures of fenoprop + endothal K salt have given outstandingly good results. -Weed Abstr. 14(3),1965.

150. MYRE, M.

1964. Some plants noxious on account of their invading ability; a contribution to their study. Means to avoid their dispersal and to reduce their expansion. Lourenço Marques, Instituto de Investigação Cientifica de Moçambique, Junta Provincial de Povoamento, 32 p. Plates. Refs.

The main noxious weeds of Mozambique are briefly discussed. Descriptions with notes on their occurrence and economic importance, are presented of Lantana camara, Eichhornia crassipes, Cannabis sativa and Acanthospermum hispidum; literature on their control, with special reference to Africa, is reviewed, and measures necessary to prevent their spread in Mozambique are discussed. The text is concluded by English and French summaries (½ page each) and a list of 22 refs., and followed by 36 photographs, part of which are in colour, showing the growth habit and other botanical characteristics of some weed species. -Trop. Abstr. 20(12),1965.

151. NAG RAJ, T.R.

1965. Thread blight of water hyacinth. Current Sci. 34(21): 618-9.

Eichhornia crassipes in Kerala State (India) was found to be attacked by a fungus subsequently isolated and identified as Marasmiellus inoderma. All aerial parts of the plants were overrun by thick, white, radiating strands of mycelium; affected parts later became necrotic, and the plants rotted or dried up depending upon the prevailing weather conditions. The infection was most evident in dense stands of the weed; death of the plants occurred in irregular patches. On account of its rapid spread the fungus is thought to hold promise for the biological control of the water hyacinth whereas 4 other fungi known to attack the weed in India do not. Photos. 2 refs. Trop. Abstr. 21(4), 1966.

152. NAG RAJ, T.R. and PONNAPPA, K.M.

1967. Some interesting fungi of India. Tech. Bull. Comm. Inst. Biol. Control, 9:31-44. (Bibl. 1; Commonwealth Institute of Biological Control, Bangalore, India)

During a search for natural enemies of water hyacinth (Eichhornia crassipes) and other equatic weeds, fungi were observed on living plants as follows: Cercospora sp. on Rotala densiflora; Cerdospora sp. and Sclerotium rolfsii on Pistia stratiotes; Corticium solani and Glomerella cingulata on Alternanthera sessilis; C. solani and S. rolfsii on Cyperus sp.; C. solani and Myrothecium roridum on E. crassipes; C. solani on Ludwidgia parviflora; C. solani, Glomerella cingulata, Rhizoctonia lamellifera and Physoderma nelumbii on Nymphaea stellata; Fusarium sp. on Sagittaria guayanensis; M. roridum and S. rolfsii on Nelumbo nucifera; Oidium sp. on Eclipta alba; and Sphaerulina limnanthemi on Limnanthemum (=Nymphoides) indicum. -Weed Abstr. 17(4),1968.

153. NAG RAJ, T.R. and PONNAPPA, K.M.

1970. Blight of water-hyacinth caused by Alternaria eichhorniae sp. nov. Trans. Brit. Mycol. Soc. 55(1):123-130.

Alternaria eichhorniae sp. nov. is characterized by chromogenesis in culture, surmaturation of conidia and absence of gemmae. Pathogenicity to water-hyacinth (Eichhornia crassipes) is demonstrated by inoculation experiments, and the morphology, cultural behavior, toxicity of metabolites, host range and virulence are fully described. -Biol. Abstr. 52(1),1971.

154. NAIDU, B.A., MURTY, M.S. and RAO, I.V.S.

1965. Note on the control of water hyacinth by hormonal herbicides. Andhra Agric. J., 12(1):22-8, bibl. 13. (Agric. Coll., Bapatla, India)

One application of Fernoxone (2,4-D Na 80%) at 10#, Weedone LV-4 (2,4-D butoxyethanol ester 4 lb a.e./gal) at 2 gal/ac or Bladox-O (amitrole, 2,4-D) at 8 l./ac, each in 150 gal spray, decomposed actively growing water hyacinth (Eichhornia crassipes) at a respective cost of Rs 25, 168 and 100 (1 rupee = 1s. 6d.). -Weed Abstr. 15(5/6), 1966.

155. NELSON, M.L., GANGSTAD, E.O. and SEAMAN, D.E.

1970. Potential growth of aquatic plants of the lower Mekong River Basin. Laos-Thailand. Report: prepared for the U.S. Agency for International Development, Feb. 1970, 34 p.

The extent of future weed interference with operation and maintenance of the Pa-Mong project in Laos-Thailand was assessed. Eichhornia crassipes, Pistia stratiotes and Salvinia cucullata were observed in large quantities at different locations. It is recommended that ponds, streams, etc., in the area upstream of the damsite be treated with herbicides prior to the filling of the reservoir to give some preventive control. Irrigation channels should be constructed with access routes to allow efficient mechanical control measures.

It is suggested that a research team (weed scientist, entomologist and plant pathologist) should commence on a 10-year research program of solving specific weed problems by mechanical, chemical and biological control as they arise. The teams should be based at Khon Kaen where reservoirs are available for such research. -A.H.

156. NEOGI, S. and RAJAGOPAL, K.

1949. A method for the production of carotene concentrate from Water Hyacinth (Eichhornia crassipes, Solms.). J. Sci. Ind. Res. 8B(7):119-21.

A method, developed on the laboratory scale; for production of carotene concentrate from water hyacinth (Eichhornia crassipes) is described. Stages are dehydration of leaves, organic solvent extraction of total pigment, purification of the extract by chromatographic separation, recovery of the solvent and storage of carotene.

Several methods of dehydration were tried. Chopping and blanching leaves before oven drying speeded up dehydration and raised the yield of carotene by about 42%. Higher yields were obtained from extractions using high boiling petroleum ether (b.p. 80-100°C), with direct heating over a water bath than from extractions with petroleum ether (b.p. 40-60°C) in a Soxhlet apparatus. In chromatographic separation, good results were obtained with a mixed absorbent of soda ash and light magnesia using petroleum ether (b.p. 40-60°C) as solvent. Orange and yellow bands were taken together as total carotene.

The method yielded 143 mg. from 3 kg. fresh leaves. An analysis following the method of Moore on fresh leaves indicated this to be about 84% recovery. The carotene was kept in sealed bulbs wrapped in black paper. Rats maintained on a vitamin-A free diet for 6 weeks showed a graded weight gain on being fed the test product. -A.H.

157. NEW ZEALAND DEPARTMENT OF AGRICULTURE.

1961. Rep. Dept. Agric. N.Z., 1961, 33 p.

Weed control. Water hyacinth (Eichhornia crassipes), Cape tulip (Homeria spp.), and Russian knap-weed (Centaurea repens) are now all well under control. Recommendations for dalapon + amitrole mixtures can be given for most drain clearance work. For floating and submerged aquatic weeds, fenoprop is satisfactory in ponds, but has been unsatisfactory in large lakes.

Improved formulations of 2,4,5-T have given good results against gorse (Ulex sp.).

P. 40. Simazine and atrazine at 3# have given excellent control of broad-leaf weeds, but no control of Digitaria sanguinalis or Panicum capillare. In carrots, propazine controlled the broad-leaved weeds, but not the grasses, whereas chlorpropham 4# controlled the grasses, but not Amaranthus retroflexus. A combination of chlorpropham and sodium monochloroacetate was the most promising treatment in onions. Contrary to the results in 1960, Amiben (3-amino-2,5-dichlorobenzoic acid) gave unsatisfactory weed control in marrow-stem kale.

Residual effects. Dalapon at 5# sprayed on bare ground was toxic to ryegrass and white clover sown 2 weeks later; amitrole 2# had little effect on ryegrass, but was toxic to white clover. Similar treatments applied to pasture had little effect on sowings made 2 weeks later, but caused toxicity to sowings made on the same day. When the interval between spraying was 7 days or less, 50 pints of water or more reduced but did not eliminate toxicity. Watering up to 200 pints was less effective in reducing toxicity than increasing the intervals between spraying and sowing up to 14 days. Dalapon + fenoprop was much more toxic than dalapon + amitrole, particularly to seedlings of white clover, lucerne and marrow-stem kale.

P. 86. Strawberries. More than a quarter of Auckland's acreage was treated with methyl bromide in the year under review.

P. 93. Bulbs. Chlorpropham at 4# pre-em. has become standard practice for bulbs such as iris, hyacinths and tulips. Monuron 2# is used regularly in narcissus. -Weed Abstr. 11(6),1962.

158. OBEID, M. and CHADWICK, M.J.

1964. Some factors affecting the growth of two aquatic weed species of the Nile water hyacinth and water lettuce. Proc. 7th Br. Weed Control Conf., 548-52, tabs. 1, bibl. 17. (Univ. Khartoum, Sudan)

A study of the growth of E. crassipes and P. stratiotes in water culture in a factorial experiment with pH values of 4, 5.5 and 7 and N levels of 1, 5 and 25 ppm. showed that a general increase in the numbers of plants of both species and in their total dry-weights occurred at the higher N levels and a further increase where the pH was also optimum (pH 7 in the case of E. crassipes and pH 4 in that of P. stratiotes). Unlike E. crassipes, P. stratiotes did not also respond to high N and optimum pH with an increase in the weight of individual plants. The high pH (7 or above) or most stretches of the White Nile would thus seem to provide ideal growing conditions for E. crassipes and the restriction on the size of individual plants of P. stratiotes where good growing conditions lead to overcrowding suggests that the latter may be at a disadvantage wherever it is obliged to compete with E. crassipes. -Weed Abstr. 14(2),1965.

159. ORLANDI, W.

1968. The use of Eichhornia crassipes in the production of yeast, feeds and forages. FAO, in Handbook of utilization of aquatic plants - A compilation of the world's publications, 1968, 58-61.

160. ORNDUFF, R.

1966. The breeding system of Pontederia cordata L. Bull. Torrey Bot. Club, 93(6):407-416. Illus.

The results of an artificial pollination program demonstrate the presence of an incompatibility system in Pontederia cordata L. (Pontederiaceae), which is a tristylous member of the Monocotyledoneae. Self-incompatibility is apparently strongest in the short-styled form, slightly weaker in the long-styled form, and much weaker in the mid-styled form. Corresponding differences in the strength of incompatibility were also noted in "illegitimate" cross pollinations among the 3 floral forms. Fruit production following interform pollinations between anthers and stigmas at an equivalent level (i.e., legitimate pollinations) was markedly higher than from illegitimate ones, although not as high as expected. Observations on inflorescences collected in the field indicate that fruit production under natural conditions exceeds that of artificially, legitimately pollinated plants in the greenhouse. In most field populations examined all 3 floral forms were present, although in many instances the forms were unequally re-represented. Possible explanations are offered to account for this in-equality. The reproductive floral morphology of other taxa of Pontederiaceae is reviewed and the conflicting reports for several species pointed out. The breeding system of Pontederia cordata is compared with that of the related Eichhornia crassipes, although data for the latter species are incomplete. -Biol. Abstr. 48,1967.

161. OYAKAWA, N. and others

1965. The use of Eichhornia crassipes in the production of yeast, animal rations and forage. (Pap. read at) 9th Int. Grassl. Congr., São Paulo, 5 p., bibl. 10. (Por) (Secretaria de Abastecimento, Prefertura do Municipio de São Paulo, Brazil).

A scheme is proposed for using the washed, crushed, sterilized and extracted leaf material of E. crassipes as a substrate for the production of yeast for human and animal consumption. The yeast employed is a bottom fermenter isolated from the surface of plants of E. crassipes in course of decomposition and resembling Saccharomyces cerevisiae var. ellipsoideus. Fermentation may be made continuous by withdrawing the yeast crop at intervals and supplying fresh quantities of sterile substrate. After separation and dehydration, one kg. of fresh plant material is estimated to yield 12 g. of pure yeast containing 52.7% protein. If mixed with the bagasse remaining after extraction of 1 kg. of fresh plant material, the result is a balanced animal feed containing not less than 28% protein. -Weed Abstr. 15(1), 1966.

162. PAIXAO, J.C.

1959. Use of herbicides in the cleaning of ditches and canals in the Sepetiba lowlands, Brazil. An. Semin. Brasil Herbicidas Ervas Daninhas 1958, 147-54, bibl. 7.

Eichhornia crassipes was controlled by 2,4-D amine and 2,4,5-T ester (each at 1%). TCA 90% (400 g/15 l water) controlled Eleocharis sp. while Cyperus spp. and rhizomatous grasses, including Imperata brasiliensis, were controlled by monuron (20 kg/ha) or 2 applications of monuron + 2,4-D. -Field Crop Abstr. 15(2),1962.

163. PARIJA, P.

1934. Physiological investigations on water-hyacinth (Eichhornia crassipes) in Orisa with notes on some other aquatic weeds. Indian J. Agric. Sci. 4(3):399-429.

The seeds of water hyacinth remain dormant at least for one season, i.e., from November to June, and retain their viability for several years. The embryo is fully developed before the capsule bursts. There is an optimum range (6° - 8°) of hydrogen-ion concentration in which water hyacinth thrives. Any deviation from this range affects the growth adversely, large alteration resulting in the death of plants. Calcium salts probably antagonise the effect of hydrogen-ion concentration, and that is the reason why sometimes plants are not killed by changing the hydrogen-ion concentration. Water hyacinth is able to resist a considerable degree of drought and survives even when the water content of the soil falls as low as 5.7% of the saturation value. Effect of poisons, especially copper sulphate, was found to be 0.018%.

Application of copper sulphate affects the roots and makes the absorption lag behind transpiration. -A.H.

164. PARKER, C.

1969. Weed control. Rep. SEATO Reg. Agric. Res. Project (Vol. 2-Reps. of Consultants), Bangkok, Annex B 3, 20 p. (SEATO Consultant in Weed Control, A.R.C. Weed Res. Org., Yarnton, Oxford, OX5 1PF, England)

Government authorities are slow to accept the importance of full-time weed control work in S.E. Asia and herbicide development is largely left to the private sector. Recommendations for training include the awarding of SEATO scholarships in weed research, tenable at the University of the Philippines.

E. Pakistan. In trials, propanil increased rice yields by 40% compared with traditional methods of weed control. Weed problems in white jute (Corchorus capsularis), tosa jute (C. olitorius), sugar-cane, and other field, perennial and forest crops are reviewed, Mikania scandens, Imperata cylindrica, and Borreria hispida are particularly serious in young tea plantations. Until 1970 (at least), there will continue to be a 100% subsidy on pesticides for use in agriculture (excluding tea) but 2,4-D is the only fully registered herbicide; propanil and paraquat are now resistered for large-scale trial use. 2,4-D is used to control Eichhornia crassipes mainly, as well as Celosia argentea in rice. Paraquat, forced by import restrictions to 3 times (£25/gal) its normal cost, is still proving quite popular in tea. Identification of weeds by official researchers is reported as erratic; many records for Cyperus rotundus and all records for C. esculentus were erroneous. Lines for expansion of weed research activities are suggested.

Thailand. About 85% of the rice crop is transplanted and about 20% of this is sprayed with 2,4-D sodium. Weeds of direct-sown rice include Leptochloa chinensis as well as Echinochloa spp. Atrazine has been successfully tested against Pennisetum polystachyum, P. pedicellatum and Euphorbia geniculata in maize and sorghum. Trifluralin has shown great promise in cotton although broad-leaved weeds such as Euphorbia spp. are not controlled; trifluralin is also suggested for kenaf (Hibiscus cannabinus). Pre-em. treatment with 2,4-D is recommended in sugar-cane.

Herbicides are being sought to replace methyl bromide for controlling weeds in tobacco nursery seed-beds. Larger estates are already using trifluralin in cassava (Manihot esculenta). Fruit crops are infested with I. cylindrica, Brachiaria mutica and Panicum repens. 2,4,5-T is being supplied free to growers to destroy old rubber trees, plus dalapon to control grass weeds, before planting, sodium arsenite is used in quantity. I. cylindrica, Eupatorium odoratum, Pennisetum spp. and Setaria spp. are problem weeds in young forest plantations. Coix sp. and E. crassipes are the main aquatic weeds.

Philippines. In rice, 2,4-D and MCPA are commonly used for the control of annual sedges and broad-leaved weeds but a strain of Echinochloa crusgalli is resistant and has some ability to germinate under water. Trifluralin + MCPA is the most successful mixture so far tested. Trials in maize have shown that one of the most important annual weeds, Rottboellia exaltata, is semi-resistant to atrazine. The large sugar-cane estates are using 2,4-D, diuron and paraquat to control annual grasses and Cyperus rotundus, C. rotundus is a very common problem in upland crops. A few large pineapple and banana plantation owners are using substantial amounts of diuron and paraquat which they find economical despite the cheapness of labour. The International Rice Research Institute is protecting pre-germinated rice seed with activated charcoal before direct sowing into mud

so that paddies can be safely treated with strong pre-em. herbicides before sowing. There is little research in weed control outside of the University of the Philippines-Los Banos complex. -Weed Abstr. 19(3), 1970.

165. PARSONS, W.T.

1963. Water hyacinth, a pest of world waterways. J. Agric., Vict., 61(1):23-27, figs. 5. (Vermin & Noxious Weeds Destruction Bd., Dept. Crown Lands and Survey, Victoria)

The biology and distribution of Eichhornia crassipes are reviewed briefly, together with observations on its detrimental qualities as a weed and its control with 2,4-D.

In Australia, two outbreaks of E. crassipes, one in the Murray River, South Australia in 1939 and another at Albury, New South Wales in the early 1940's, were successfully eradicated. A fresh outbreak is reported at Wangaratta in N.E. Victoria. -Weed Abstr. 12(5),1963.

166. PETERSEN, D.P. and BURGDORFF, R.E.

1967. Stull Bifluid spray system. Hyacinth Control J., (6): 6-8. (Stull Chem. Co., San Antonio, Texas).

An account is given of experience with Stull Bi-fluid system of producing invert emulsion sprays (see Weed Abstr. 12:601) for aquatic weed control. Invert emulsion formulations of 2,4-D oleyl amine at 2# in 16 gal spray/ac delivered from a helicopter, or 40 gal/ac delivered from portable power sprayers on boats, have provided excellent control of water hyacinth (Eichhornia crassipes) on a commercial scale since 1963, while in E. Texas similar treatments have been successful against alligator weed (Alternanthera philoxeroides) since 1966.

Invert emulsion treatments at present being evaluated included Ansar 170 (monosodium acid methane-arsenate 50.5%) at 2-3 lb a.i./ac premixed with the water phase + Instemul DA 120 (2,4-D oleyl amine 3 lb a.e./gal) at 2 lb a.e./ac for the control of mixed vegetation; and Ammate X (AMS) + an adjuvant (Bivert-AMX) for the control of brush on canal slopes and against submersed weeds. -Weed Abstr. 17 (4),1968.

167. PETTET, A.

1964. Seedlings of Eichhornia crassipes: a possible complication to control measures in the Sudan. Nature, Lond., 201(4918):516-17, bibl. 3.

Observations made in 1963 at various points along the White Nile between Jebel Aulia and Kosti have shown the presence of large numbers of seedlings of E. crassipes along the river banks. There are grounds for believing that the present measures for controlling E. crassipes (based on the use of 2,4-D) may themselves provide conditions particularly favourable for seedling growth. Dying E. crassipes plants are blown on to the river banks to form strand lines of decaying vegetation. It appears that these strand-line conditions promote rapid seed germination and seedling development of E. crassipes, conditions otherwise found only rarely in nature. The possible risk of infestation of irrigation schemes from seeds taken from the river banks where E. crassipes seed has become concentrated is noted. -Weed Abstr. 13(2),1964.

168. PICKWORTH, G.

1969. Water hyacinths in farm dams--a serious problem. Farming S. Africa, 45(3):13, 15.

In a farm dam in Natal, the water hyacinth (Eichhornia crassipes) was almost completely eradicated within 5 months after the first chemical treatment. The aquatic spray unit and the technique used are described. The control measures comprised an initial spraying with 337.5 l., followed 3 weeks later by a spraying of 125 l., and 3 months later by an application of 62.5 l., of a preparation containing 225 g a.i. 2,4-D ester/112 l. of water. -Weed Abstr. 19(5),1970.

169. PIERCE, P.C.

1967. Results of field testing diuron as an effective herbicide for the control of vascular aquatics. Proc. 20th Sth. Weed Conf., 327-33. (Bibl. 3; Georgia Game and Fish Commn., Fort Valley)

An 80% w.p. and a 20% granular formulation of diuron gave excellent control of Lemna minor, Najas marina, Potamogeton diversifolius, Typha spp., Utricularia sp. and mixed marginal grasses and sedges in ponds at concns. down to about 0.13 ppm. Pithophora sp., Hydrodictyon sp., Chara sp. and non-branched, filamentous algae were also effectively controlled, but Eleocharis acicularis, Myriophyllum heterophyllum, M. brasiliense, Eichhornia crassipes and Proserpinaca sp. were resistant to the concns. tested (0.06-1 ppm). In one trial, marginal vegetation, including grasses, mixed sedges, duckweed (Lemnaceae) and cattails (Typhaceae), was controlled by diuron granules applied along the shoreline in water <1 ft deep. No advantage was gained in using monuron rather than diuron for the control of L. minor. Laboratory studies indicated that the response of L. minor to sub-lethal concns. of diuron was unaffected by total hardness ranging from 10 to 105 ppm. and pH from 7 to 9. -Weed Abstr. 18(2),1969.

170. PIRIE, N.W.

1960. Water hyacinth: a curse or a crop? Nature 185(4706): 116.

The recent explosion of water hyacinth (Eichhornia crassipes) in S.E. Asia, the Nile and the Congo has led to various attempts at eradication. The possibility of utilizing this pest as a crop until new predators have restored a balance is discussed.

Water hyacinth differs from other weedy crops in producing a pure stand, making harvesting consistent and easy. The floating state is ideal for mechanized harvesting.

Possible uses are as cattle and pig feed and as compost after fermentation. Although this has not been demonstrated, it is reasonable to suppose that water hyacinth would yield satisfactory levels of protein. Its high water content at harvest might prove an asset in protein extraction which is easier from wet than from dry leaves. Such a process would involve extraction of juice and coagulation of protein. -A.H.

171. PONNAPPA, K.M.

1970. On the pathogenicity of Myrothecium roridum-Eichhornia crassipes isolate. Hyacinth Contr. J., 8(2):18-20. (Bibl. 38; Commonw. Inst. Biol. Control, Bangalore, India).

The fungus, grown on potato-dextrose-agar and stored at room temperature, remained viable for over 2 years. Plants from 19

genera were tested and all except Vinca rosea, Calotropis gigantea, coffee and kohl rabi were susceptible. Chilli (Capsicum frutescens (=C. annuum)), potato, rice and castor beans were new host records for the fungus. Because of its wide range of pathogenicity the fungus cannot be used for biological control. -Weed Abstr. 20(4),1971.

172. RAMACHANDRAN, V. and RAMAPRABHU, T.
1966. Investigations on aquatic weed control with special reference to the use of chemicals. (Pap. read at) FAO World Symp. on warm-water pond fish culture, Rome, 17 p. (Bibl. 29; Central Inland Fish. Res. Sub-Stn., Cuttack, India)

Water hyacinth (Eichhornia crassipes). In India this is the only species which can render water areas unusable. It may be controlled with Taficide-80 (2,4-D sodium 80%) at 4-6 kg/ha + Surf detergent (0.25% in solution). Simazine 5 kg/ha a.i. is effective but considered too expensive. In rural areas manual eradication is employed. Other floating weeds. Pistia stratiotes, Spirodela polyrhiza, Lemna minor, Azolla pinnata and Wolffia arrhiza do not pose any serious problem and may be cleared manually. They may also be controlled with ammonia, at a concn. of 40 ppm., applied near the surface. Emergent weeds. Rooted species such as Nymphaea nouchali, N. stellata, Nelumbo nucifera, Nymphoides cristatum and N. indicum are most important. Nymphaea spp. may be controlled by one application of Taficide-80 at 1.5% + Surf detergent 1% aqueous solution. Nymphoides spp. were defoliated by Taficide-80 at 2.5% but a large number of plants regenerated. Banks and shallow water. Species include Cyperus spp., Phragmites sp., Eleocharis sp., Panicum sp., Colocasia antiquorum and Ipomoea aquatica. Taficide-80 at 1% and Tafapon (dalapon sodium 85%) at 28 kg/ha controlled young Cyperus sp. but not older plants. 2,4-D in 2.5% aqueous solution checks Eleocharis plantaginea. In the laboratory Panicum fluitans was killed by root applications of 2,4-D and simazine. Taficide-80 at 1.5% checks C. antiquorum which becomes uprooted and floats. It should then be removed by hand as it may revive. Planktonic algal blooms. The most important is the blue-green alga, Microcystis aeruginosa. Preliminary experiments show that it may be controlled by simazine at 0.5-1 ppm. Submerged weeds The most important include Hydrilla verticillata, Najas graminea, N. indica, Ceratophyllum demersum, Vallisneria spiralis and Potamogeton spp. They are usually cleared manually but regeneration is rapid. Sodium arsenite at a concn. of about 6 ppm has also given good control. Ammonia at 15 ppm has given > 93% control of Hydrilla verticillata which may also be controlled by simazine 3-5 ppm and Aquathol (endothal 19%) (rate not stated). See also Weed Abstr. 11:140.

The literature is reviewed and discussed. -Weed Abstr. 17(5), 1968.

173. RAMAN, K. and NARAYANASWAMY, S.
1970. Growth in axenic culture of isolated shoot apices of Eichhornia crassipes. Physiol. Plant. 23(1):154-58. Illus.

Apical meristem culture of E. crassipes showed that for successful regeneration, the excised meristem dome must be associated with at least the youngest leaf primordium as part of the explant and a culture medium containing coconut milk (10%, v/v), IAA (0.1 mg/l) and kinetin (1 mg/l) as growth supplements with 2% sucrose as C source. -Biol. Abstr. 51,1970.

174. RAO, V.P.

1964. US PL-480 project: survey for natural enemies of witch weed and water hyacinth and other aquatic weeds affecting waterways in India. Report for the period January to December 1964. Rep. Commonw. Inst. Biol. Control, Indian Stn., (n.d.), 94 p. bibl. 36. (Commonw. Inst. Biol. Control, Bangalore, India)

Several insects and pathogens attacking Striga spp., Cyperus rotundus and aquatic weeds, including Eichhornia crassipes, were studied in India during 1964. The gall-forming weevil Smicronyx albovariegatus was a very common and widely distributed insect on Striga angustifolia, S. densiflora and S. lutea in parts of Andhra Pradesh, Mysore State and Gujarat. The incidence of the weevil as high in Sorghum vulgare at Ranebennur in Mysore State, but despite heavy infestation, galled plants did not compare unfavourably with healthy plants in respect of height, general growth and number of fruit pods produced. A noctuid caterpillar Eulocastra argentisparsa fed on the seeds of all the three species of Striga but its incidence was low. The stem borers Bactra minima and Schoenobius sp. were recorded on Cyperus rotundus.

E. crassipes was attacked but not controlled by the grasshopper Gesonula punctifrons. The insect also attacked tender maize leaves but not sugar-cane. A noctuid Namangana pectinicornis appeared to be suitable for the biological control of Pistia stratiotes. However, partial destruction of the weed by the caterpillars has been reported to encourage the breeding of Mansonioides, a vector of the filarial worm Brugia malayi, and its use is therefore not desirable in areas where filariasis is prevalent. Since a partial or gradual reduction of the weed may promote mosquito breeding, it is suggested that N. pectinicornis might be tried in conjunction with such larvivorous fish as Gambusia sp., Lebistes sp. and Nothobranchius sp.

A defoliating beetle Haltica caerulea and a fruit-infesting weevil Nanophyes sp. (=N. nigritulus?) caused appreciable damage to Jussiaea repens. H. caerulea also attacked J. suffruticosa and Ludwigia sp., while N. nigritulus was reported feeding on J. suffruticosa. H. caerulea dis not attack paddy, sugar-cane or maize.

Of the several pathogens studied, the fungus Corticium solani infected E. crassipes, Nymphaea stellata, Alternanthera sessilis and Ludwigia parviflora, of which E. crassipes suffered severe injury. Sclerotium rolfsii attacked Pistia stratiotes and Myrothecium roridum attacked E. crassipes but both these fungi were pathogenic to several economic plants. Other pathogens which showed promise were Cercospora sp. on Striga lutea and, to a lesser extent, on S. densiflora, an unidentified Basidiomycete occurring on E. crassipes, and Sphaerulina sp. on Nymphoides indicum. -Weed Abstr. 15(5/6),1966.

175. RAO, V.P.

1968. Evaluation of natural enemies associated with witchweed, nutsedge and several other aquatic weeds occurring in India. India, Commonwealth Inst. of Biol. Control, Report for the period June 21, 1968-July 31, 1969, 16 p. (U.S. PL-480 Project)

The project is evaluating certain promising pests of aquatic plants in India for possible importation into the USA while continuing to survey pests in different areas: Andhra Pradesh, Assam,

Kerala, Mysore, Rajasthan, Tamil Nadu and West Bengal. Although many aquatic weeds have been studied, special attention was paid to witchweed (Striga sp.) nutsedge (Cyperus rotundus) and willow primrose (Ludwigia adscendens)

Eulocastra argentisparsa, a pest of Striga sp., showed some feeding on Antirrhinum but could not complete its life cycle on this plant: the brown and green forms of this pest may belong to different species. Haltica caerulea and Nanophyes spp., pests of L. adscendens failed to thrive on ornamental plants in the family Onagraceae and on tobacco. H. caerulea appears to prefer an aquatic habitat. A new species of fungus, Alternaria eichhorniae was found attacking Eichhornia crassipes. -A.H.

176. RAO, V.P.

1969. The problem of aquatic weeds in India. Plant Protection Bull. 21(4):1-8.

Aquatic weeds are a serious problem in inland waters in India: they pollute drinking water, provide breeding sites for mosquitoes and snails and interfere with fish culture and navigation. Examples of foreign weeds which have been introduced and have undergone population explosions in the last 50 years are Ludwegia sp. from America and Alternanthera philoxeroides from South America.

Recent investigations in India have shown that water weeds have a role in spreading dangerous pests and diseases: e.g. Eichhornia crassipes carries Attractomorpha crenulata (tobacco, brinjal, jute) and Rhizoctonia solani (brinjal).

Chemical control is used little in India and there will be no additional funds available for its use in the next few years. In the last 6 years, the Commonwealth Institute of Biological Control has been surveying pests as possible biocontrol agents. Large populations of Gesonula punctifrons attack E. crassipes in India. Host specificity tests are being conducted on Chilo ignitalis, Neochetina bruchi and Orthogalumna terebrantis with a view to importing them from South America to control this weed. Promising biocontrol agents of Ludwigia adscendens and Pistia stratiotes are Haltica caerulea and Nanophyes sp. nr. nigritulus and Namangana pectinicornis respectively. In West Bengal, Alternanthera philoxeroides is defoliated by larvae of Psara basalis; Agasicles sp. may be suitable for introduction from South America. Ctenopharyngodon idellus, native of China, has been shown to feed on many aquatic weeds. -A.H.

177. RAO, V.P. and others

1970. Biological control of Eichhornia crassipes and other aquatic weeds. India, Commonwealth Institute of Biological Control, Report for the year 1970, 10 p.

Species of insect pest of Eichhornia crassipes were imported by India for laboratory trials; Acigona ignitalis, Epipagis albiguttalis, Neochetina sp. from the West Indies and Orzama densa and Orthogalumna terebrantis from Florida. Details of laboratory rearing, life histories, damage to water hyacinth and host specificity are given. Problems were encountered with diseases, especially with the first 2 species and A. densa in which a bacterial disease was successfully eliminated by incorporating streptomycin sulphate in the diet.

Most species were host specific to E. crassipes: although larvae of A. ignitalis and adults of Neochetina sp. also fed on Musa paradisiaca and Canna orientalis they could not complete their life cycles on these plants. Of the borers, A. ignitalis had a high fecundity and each larva could destroy 14 plants; A. densa larvae were gregarious and could kill entire plants more rapidly; E. albiguttalis larvae had less destructive power but the multivoltine life cycle of the species could be useful in building up field populations.

Ctenopharyngodon idella was successfully cultured in the laboratory. The carp fed on Hydrilla verticillata, Vallisneria spiralis, Najas minor and Potamogeton perfoliatus but not on P. nodosus. -A.H.

178. RAYNES, J.J.

1964. Aquatic plant control. Hyacinth Contr. J. (3):2-4.

The spread and economic importance of water hyacinth (Eichhornia crassipes) and alligator weed (Alternanthera philoxeroides) in the USA are briefly reviewed, together with the programme for their control administered by the US Army Engineers. -Weed Abstr. 15(2), 1966.

179. RAYNES, J.J.

1965. Aquatic weed research navigation and flood control. Proc. 18th Stn. Weed Control Conf., 475-8, bibl. 5. (US Army Crops of Engineers, Atlanta, Georgia)

Chemical and mechanical control of aquatic weeds infesting navigation and drainage canals in the USA is briefly reviewed. Weeds considered include water hyacinth (Eichhornia crassipes) alligator weed (Alternanthera philoxeroides) Eurasian watermilfoil (Myriophyllum verticillatum) and water chestnut (Trapa natans). -Weed Abstr. 15(2),1966.

180. RIOPEL, J.L.

1969. Regulation of lateral root positions. Bot. Gaz. 130(2): 80-83. Illus.

Potential sites for the origin of lateral roots are influenced by the position of the previously established lateral. Distribution studies conducted on 6 monocot species (Alpinia speciosa, Heliconia aurantiaca, Eichhornia crassipes, Ravenala madagascariensis, and Zingiber spp.) consistently show lateral roots organized in a non random, dispersed pattern. Further measurements indicate a three-dimensional zone of suppression near lateral root positions. -Biol. Abstr. 51,1970.

181. ROBINSON, P.E.

1965. Dam B reservoir water hyacinth control. Proc. 18th Stn. Weed Control Conf., 464-8, bibl. 2.

A programme initiated in the spring of 1963 by the US Corps of Engineers for the control of water hyacinth (Eichhornia crassipes) infesting a reservoir in E. Texas resulted in approximately 35% control by the winter of 1964. Sprays applied with a helicopter cost approximately $9.5/ac using 2,4-D amine invert emulsion, and $6.5/ac using 2,4-D water soluble amine. -Weed Abstr. 15(2),1966.

182. ROBSON, J.W. and PROCTOR, G.C.
1963. Paraquat as a herbicide and desiccant in tropical agriculture. World Crops, 15(6):264-8. (I.C.I. Plant Protection Ltd.)
Notes are given on the use of paraquat in sugar-cane (for post-em. use in crops not less than 3 ft high and for pre-harvest desiccation), for controlling water weeds including Pistia stratiotes, Eichhornia crassipes and Salvinia auriculata, submerged weeds and algae, for controlling weeds in rubber, citrus, coffee, oil palms and bananas and for sward destruction prior to pasture renovation. -Weed Abstr. 12(5),1963.

183. ROGERS, J.D. and DOTY, J.W.
1966. Aquatic weed control in the Sub-Drainage Districts of the Florida Everglades. Hyacinth Contr. J., 5:26-9.
An account is given of the role of herbicides for the maintenance of drainage facilities in a number of Sub-Drainage Districts of the Florida Everglades. Standard Chemical treatments employed include 2,4-D for the control of Eichhornia crassipes, fenoprop for the control of Alternanthera philoxeroides, acrolein and emulsifiable solvents for the control of submersed species, and dalapon and 2,4,5-T for the suppression of ditchbank weeds. -Weed Abstr. 16(4),1967.

184. ROSTRON, A.
1968. Water hyacinth: noxious weed that must be checked. N.Z. J. Agric., 117(6):51. (Dept. Agric. Kaitaia, New Zealand)
Infestations of water hyacinth (Eichhornia crassipes) have been identified at Hokianga and Mangonui Counties in New Zealand additional to existing small infestations of the weed throughout the country. Means of identifying the plant are described and the need for prompt action in reporting outbreaks emphasized. -Weed Abstr. 18(4),1969.

185. SAHAI, R. and SINHA, A.B.
1970. Contribution to the ecology of Indian aquatics: I. Seasonal changes in biomass of water hyacinth (Eichhornia crassipes (Mart.) Solms). Hydrobiologia 35(3/4):376-382.
A detailed account of the seasonal changes in vegetational cover, rate of biomass change and production of E. crassipes, growing under natural conditions in a permanent lake ('Ramgarh') of Gorakhpur (Uttar Pradesh) India, is given. The observations indicate that: the maximum biomass is in mid-winter months after the flowering period is over and the maximum cover is in the post-winter months after the maximum biomass period; the annual net production is 103.0 g organic matter/m^2; and the maximum rate of biomass change is 3.8 g organic matter/m^2. -Biol. Abstr. 52(6),1971.

186. SANCHEZ, O.A.
1962. Communication on the performance of the first applications of diquat and paraquat (desiccants, defoliants and general herbicides) in Argentina. An. 4° Seminario Brasileiro de Herbicidas e Ervas Daninhas, 79-83, bibl. 4. (Span). (Industrias Quimicas Argentinas "Duperial" S.A.I.C., Buenos Aires, Argentina)
Diquat at 0.8 kg in 120 l. water provided better desiccation of a seed-crop of lucerne than did dinoseb at 1.375 kg in 100 l. diesel oil/ha. Sagittaria montevidensis, Gymnocoronis spilanthoides,

Eichhornia sp., Pontederia sp., Duchesnea indica, Pistia stratiotes and Eryngium serra in and near canals responded to paraquat at 1 kg in 833 l. water/ha, but Paspalum urvillei and Scirpus giganteus were resistant. -Weed Abstr. 13(4),1964.

187. SANKARAN, T.; SRINATH, D. and KRISHNA, K.
1966. Studies on Gesonula punctifrons Stal. attacking water hyacinth in India. Entomophyga, 11(5):433-40.

In a survey of natural enemies of Eichhornia crassipes in India; Gesonula punctifrons was found to be the most common insect attacking this weed in Mysore State, Orissa, Andhra Pradesh, Madras State, Kerala and Assam.

The grasshopper was also found feeding on Monochoria vaginalis and Colocasia sp. both of which have a moist, spongy petiole interior necessary for egg hatching. Oviposition holes of varying size occur 4" to 12" above the water level. Eggs are glued together in a group: incubation period varies from 3 to 4 weeks. Nymphs moult 5 times (total of 34 days). Adults live for 4-5 months feeding almost exclusively on water hyacinth. G. punctifrons has not been recorded on water rice in India.

Laboratory feeding tests were conducted on 42 plants in 27 families. The insect could feed on a wide range of economic plants, the level ranging from heavy on Canna orientalis to light on Beta vulgaris, Brassica oleracea capitata, Morus indica, Solanum tuberosum, etc. However oviposition and completion of the life cycle only occurred on water hyacinth and the 2 species mentioned above. -A.H.

188. SANKARAN, T. and others
1969. Evaluation of natural enemies associated with witchweed, nutsedge and several other aquatic weeds occurring in India. India, Commonwealth Institute of Biological Control, Report for the period August 1, 1969-July 31, 1970, 19 p. (U.S. PL-480 Project)

In this continuing project, insect and fungal enemies collected in India on Striga spp., Cyperus rotundus and Eichhornia crassipes were tested for host specificity with a view to introduction to the USA. Also areas of Mysore State and Assam were surveyed for aquatic weeds and their pests.

Green and brown larval forms of Eulocastra specimens attacking Striga have been placed in 2 different species, E. argentisparsa and E. undulata respectively. The larvae failed to feed on 2 more species of Scrophulariaceae: Limnophila heterophylla and Bacopa monnieri. Nymphula spp. caused serious damage to Potamogeton nodosus, Nymphaea stellata and Nymphoides indicum. Larvae of N. crisonalis and N. diminutalis would not feed on rice seedlings in laboratory test. Mompha sp. nr. schrankella feeding on Ludwigia adscendens was a new report for India. A first appearance of Alternanthera philoxeroides in Bangalore was reported: Psara basalis and P. stultalis were attacking this weed. In laboratory tests, Lymnaea luteola was unable to control Hydrilla verticillata on which it fed. Alternaria Eichhorniae, causing leaf blight in water hyacinth, was unable to attack 28 other species, including representatives of Compositae, Cucurbitaceae, Euphorbiaceae, Leguminosae and Liliaceae. -A.H.

189. SANKARAN, T. and others

1970. Evaluation of natural enemies associated with witchweed, nutsedge and several other aquatic weeds occurring in India. India, Commonwealth Inst. of Biol. Control, Report for the period August 1, 1970-July 31, 1971, 18 p. (U.S. PL-480 Project).

In this continuing project, host-specificity tests were made on the more important natural enemies recorded earlier on Striga spp., Cyperus rotundus, Alternanthera philoxeroides and Ludwigia adscendens in India and areas of Mysore State, Assam, Bihar, Kashmir and Rajasthan were further surveyed for aquatic weeds and their pests.

Field populations of Eulocastra argentisparsa and E. undulata on S. lutea were low in Mysore State and Rajasthan. Larvae failed to feed on synthetic diets and no alternate food plant for these species was found. In host specificity laboratory tests, Mompha sp. nr. schankella failed to breed on Fuchsia hybrida but bred on Ludwigia octovalis, L. perennis and Oenothera rosea. Nanophyes sp. nr. nigritulus would not breed on F. hybrida and Clarkia elegans. Bactra venosana and B. minima occur on Cyperus rotundus in Bihar and B. venosana in Assam. Cassida sp. nr. enervis, which defoliates Alternanthera philoxeroides, showed inconsistent feeding and failed to breed on Gomphrena globosa, Amaranthus gangeticus and Telanthera ficoidea. Inoculated Alternaria eichhorniae produced heavy infection on maize and a mild one on sorghum. -A.H.

190. SCIENTIFIC COUNCIL FOR AFRICA SOUTH OF THE SAHARA.

1957. Eichhornia crassipes. Publ., C.S.A. (C.C.T.A.), 1957, 27, 32 p.

This is a report of a symposium on E. crassipes held in Leopoldville in 1957. The meeting heard reports on the biology and ecology of E. crassipes in Tropical Africa, the effect of E. crassipes on natural plant communities and other organisms (including human activities), the results of the eradication campaign, the means of control, the effects of treatment on natural plant communities and riverine crops, the relations between treatment and climatic conditions, possible utilization of E. crassipes, and measures to be taken to avoid invasion by other aquatic pests. It recommended inter alia: (1) further studies on conditions of growth and germination and on dissemination by vegetative means or by seed; (2) intensified study of ecological and hydrobiological conditions, particularly in the Congo basin; (3) verification in other river basins of the validity of the results; (4) preparation of a map of pH of the water in the Guinean forest area; (5) investigation locally and in the Amazon basin into means of biological control; (6) maintenance of cleared reaches and of conditions of navigability of all river waterways; (7) establishment of a Bureau by members of C.C.T.A. for studies and exchange of information by African territories concerned; (8) establishment of a system of emergency warnings of new infestation foci; (9) establishment of a check on shipping entering cleared, uninfested waters; (10) the use of 2,4-D for all control campaigns; (11) comparison of formulations of 2,4-D; (12) study of the effect of sublethal concentrations of 2,4-D on E. crassipes; (13) consideration of the use of aircraft, and of the combined use of aircraft and river

craft, and of the possibility of improving spraying equipment; (14) various precautions in cotton growing areas; (15) further study of the relations between climate and treatment and the biological cycle of E. crassipes; and (16) publication of a pamphlet describing Salvinia auriculata and Alternanthera philoxeroides, with advice as to destruction of foci. -Weed Abstr. 11(6),1962.

191. SCOTT, R.A.
1968. Resume of the Corps of Engineers' nationwide aquatic plant control program. Proc. 22nd NEast Weed Control Conf., 170-6. (Bibl. 6; Dept. Army, Washington, D.C. 20315)
The problem and extent of infestation by Eichhornia crassipes, Alternanthera philoxeroides and Myriophyllum spicatum is reviewed as are early mechanical control measures. The introduction of the South American flea beetle (Agasicles) and thrips to control A. philoxeroides has been a recent achievement. Control equipment is reviewed including remote-sensing devices to survey infestations (see J.E. Lukens . "Mapping of submerged aquatic vegetation in Casyuga Lake using colour aerial photography." N.Y. St. Conserv. Dept., 1967, 1-12)
Management and planning of aquatic plant control biological and other control measures and the problem of herbicide residues are discussed. -Weed Abstr. 17(6),1968.

192. SEABROOK, E.L.
1962. The correlation of mosquito breeding to hyacinth plants. Hyacinth Contr. J., (1):18-19.
Eradication of infestations of water hyacinth (Eichhornia crassipes) by spraying with 2,4-D is recommended as a means of discouraging mosquito breeding in Florida. E. crassipes promotes the spread of Psorophora spp. and Aedes spp. by restricting the movement of water and is a host plant for Anopheles quadrimaculatus, A. crucians, Mansonia perturbans, M. titillans, M. indubitans and Culex sp. - Weed Abstr. 14(6),1965.

193. SEAMAN, D.E.
1961. A comparative evaluation of formulations of amitrole and 2,4-D for control of water hyacinth. Proc. 14th Southern Weed Conf., 1961, 287-88. (U.S.D.A., Fort Lauderdale, Florida)
Amitrole T (amitrole + ammonium thiocyanate) 0.5-2# in 200 gal water/ac gave more than 90% control of Eichhornia crassipes, compared with 83% control from 2,4-D (diethanol-amine salt) 6# in 200 gal. Both herbicides were less effective when applied in 100 gal/ac. Amitrole alone and amitrole + hydrochloric acid behaved similarly and gave only 15% control at 1 lb/100 gal/ac and 50% control at 2 lb/100 gal/ac. Ammonium thiocyanate alone was totally ineffective at 3#. A 1:2 mixture of amitrole and ammonium thiocyanate gave 92% control, compared with 80% for the commercial 1:1 mixture and 56% for a 1:3 mixture. -Weed Abstr. 11(2),1962.

194. SEAMAN, D.E. and PORTERFIELD, W.A.
1962. Feasibility of controlling aquatic weeds with snails. (Abstract) Proc. 15th Southern Weed Conf., 1962, 256-7. (Plantation Field Lab., Fort Lauderdale, Florida)

In preliminary experiments in 200-gal tanks with Marisa cornuarietis, a fresh-water snail of South American origin, plants placed in separate tanks with 150 snails per half tank compartment were eaten in the following order of rapidity: Ceratophyllum demersum > Najas guadalupensis > Potamogeton illinoensis = Salvinia rotundifolia = Eichhornia crassipes > Pistia stratiotes > floating Alternanthera philoxeroides > submerged A. philoxeroides. The snails also readily ate Cabomba caroliniana and filamentous algae such as Pithophora, Spirogyra and Mougeotia. Very little damage was done to 3- and 4-week-old cultivated rice by snails having no other source of food. Younger rice plants and germinating rice seed did not survive in the presence of Marisa snails.

In a 3-plant experiment, C. demersum and S. rotundifolia were completely eaten and submerged A. philoxeroides defoliated within 5 days by 200 snails per tank. When 7 plants were placed together with 200 snails per tank for 25 days the following order of edibility was observed: N. guadalupensis > P. illinoensis > S. rotundifolia > C. demersum > submerged A. philoxeroides. The first four were completely eaten, but the fifth only partly. P. stratiotes and E. crassipes, especially the latter, gained in weight during the period.

Marisa populations of 50, 100, 200 and 400 per half tank all failed to eradicate E. crassipes, but all populations were effective in inhibiting growth and flowering; their principal action was root pruning.

S. rotundifolia was eradicated by populations of 50, 100 and 200 snails per half tank. A density of 4 or 5 snails per cu. ft of water is thought to be feasible for control under natural conditions in southern Florida.

Cassidix mexicanus, a common bird of Florida, is an important feeder on Marisa. Dense blooms of phytoplankton, composed mainly of the alga Polycystis, were apparently responsible for severe snail kills. -Weed Abstr. 12(1),1963.

195. SEAMAN, D.E. and PORTERFIELD, W.A.

1964. Control of Aquatic Weeds by the Snail Marisa cornuarietis. Weed 12(2):87-92.

Experiments were conducted in concrete tanks to evaluate the ability of the fresh-water snail, Marisa cornuarietis, to control some common aquatic weeds of southeastern United States. Weeds were placed in tanks under simulated natural conditions; submerged species Potamogeton illinoensis and Najas guadalupensis were rooted in soil while Ceratophyllum demersum was left unrooted; floating species Salvinia rotundifolia, Eichhornia crassipes, Pistia stratiotes and Alternanthera philoxeroides were floated on the water surface.

Three series of experiments tested feeding of the snail on single species, feeding preference in mixed species and effect of different numbers of snail on control. In single species runs all species were controlled except for E. crassipes, which was, however, impeded in growth. Control was most rapid in submerged species. In mixed species runs preference was shown for submerged species, initial 1-1.5 lb amounts of Najas, Potamogeton, Salvinia and Ceratophyllum being eaten in 3, 14, 20 and 22 days respectively. With reduced competition, E. crassipes showed rapid growth in the presence of the snails. In the third series, E. crassipes was not eradicated

but its growth and flowering were severely retarded by the highest population of snails. The principal action of Marisa on E. crassipes was by root pruning. In the absence of more palatable vegetation, the snail might give better control of E. crassipes in the winter when growth is slow.

M. cornuarietis did little damage to 4-week old rice plants but could cause serious losses of 1-#, 2-#, and 3-week old seedlings. Two birds spp. in S. Florida, Cassidix mexicanus and Aranus guarauna were predators of the snail. However it has a rapid reproduction rate. -A.H.

196. SEN, H.K.; PAL, P.P. and GHOSH, S.B.

1929. Studies in the ligno-cellulose group. Part I. An investigation into the constituents of water Hyacinth (Eichhornia crassipes). J. India Chem. Soc. 6(4):673-90.

Preliminary studies were made of the constituents of water Hyacinth (Eichhornia crassipes) with a view to its commercial exploitation. Particular interest was in extraction of potassium chloride and saccharification of cellulose to produce power alcohol.

Percentage composition of the air-dried plant was; moisture 13.46, ash 19.75; fats and waxes 7.7, different celluloses 42.23, lignin 11.31 and nitrogenous compounds 5.55. The ash was rich in alumina and potassium chloride (also calcium phosphate and alkali carbonate). Acetylation studies showed a delay in isolation of a triacetate solution in chloroform, suggesting a possible chemical combination between lignin and cellulose.

Ideal conditions for saccharification were tested for using different strengths of dilute H_2SO_4 with or without an initial water treatment. A problem was high levels of constituents yielding pentose which was practically unfermentable by yeast. It was found that heating 100 g. air-dried plant with 200 c.c. water at 9 atmospheres for 15 minutes effected extraction of potassium chloride and 95.3% pure KCl. Incineration of the liquid extract gave 95.3% pure KCl. Two hydrolyses of the residue with dilute H_2SO_4 (4.5 then 2.25%) gave a good yield of almost completely fermentable reducing sugar. Some experiments using concentrated hydrochloric acid gave promising results: fermentation by yeast was not inhibited by presence of chlorides in the solution. It was shown that E. crassipes contains high levels of hemi-cellulose suggesting that easier disintegration might be achieved by bacterial action.

Data for destructive distillation of the air-dried plant is given. -A.H.

197. SHARMA, A.

1971. Eradication and utilization of water hyacinth. - a review Current Sci. 40(3):51-5.

In India, the total area under water hyacinth (Eichhornia crassipes) is estimated at about 200,000 ha. Its eradication, either by physical or chemical methods is a costly and tedious process, which has to be repeated every year for indefinite periods. It has been proposed to consider the plant as a crop to be utilized for various purposes. This leads to its gradual extermination. A review is presented related to the various possibilities of the plant. The

principal uses of the plant are: (1) as fertilizer, compost and mulch; (2) as fodder, silage and food for pigs, cattle, sheep and fish; (3) as raw material for industry; and (4) as protein source and source for other chemicals. 50 refs. -Trop. Abstr. 26(9),1971.

198. SHEFFIELD, C.W.

1967. Water hyacinth for nutrient removal. Hyacinth Contr. J., (6):27-30. (Bibl. 13; Orange County Water Conserv. Dept., Orlando, Florida)

Indications that the presence of N and P in effluents is the primary cause of eutrophication in watercourses and lakes of Central Florida by promoting aquatic weed and algal growth, prompted model studies to investigate the feasibility of using water hyacinth (Eichhornia crassipes) as a means of removing the nutrients. In comparison with a standard algal pond, which removed up to 99% soluble ortho phosphates (leaving 1 mg/l.), 67% nitrate-N (leaving 5 mg/l.) and 88% ammonia-N (leaving 7 mg/l.) plant consisting of a pond containing E. crassipes, an air stripping unit and a flocculation and settling unit, with a total flow of 8 l. per day, proved considerably superior, removing >99% ortho phosphates (leaving 0.7 mg/l.), 99% nitrate-N (leaving 0.2 mg/l.) and >99% ammonia-N (leaving 0.1 mg/l.). Trials are at present in progress using a pilot plant with a throughout of 1,000 gal per day, based on the aquatic plant pond, air and coagulation process. -Weed Abstr. 17(5),1968.

199. SHEFFIELD, C.W.

1970. Eutrophication and aquatic weeds. Hyacinth Contr. J., 8(2):26-8. (Bibl. 9, Orange County Pollution Control Officer, Orlando, Florida)

Natural and artificial sources of mineral nutrient in waterways are reviewed and figures quoted for ground water, sewage treatment plant and agricultural run-off water in parts of Florida. The growth of weeds such as Hydrilla verticillata and water hyacinth (Eichhornia crassipes) is unlikely to be suppressed at ortho-phosphate levels above 0.01 mg/l. at the start of the season. As levels above this already occur naturally, control of the addition of artificial nutrients to waterways following population increases is now vital. -Weed Abstr. 20,1971.

200. SHIBATA, M., YAMAZAKI, K., and ISHIKURA, N.

1965. Eichhornin, a new anthocyanin isolated from the flower of water hyacinth. Bot. Mag. Tokyo 68(926-927):299-305. (recd. 1966)

The pale purple flower of the water hyacinth (Eichhornia crassipes) contains only 1 delphinidin glycoside. This was obtained in a crystalline state. A series of analytical experiments showed that the glycoside is composed of delphinidin (1 mol.) and glucose (2 mols), and that the latter links with the 3-hydroxyl group of the former, i.e., 3-diglucoside of delphinidin. Data described in the paper includes methods of extraction, purification and crystallization, chemical properties, elementary analysis, hydrolysis, ultraviolet absorption spectra, infrared spectra, paper electrophoresis, and R_f values. -Biol. Abstr. 48,1967.

201. SIMMONDS, F.J.

1961. Possibilities of the use of biological control methods. (Pap. read at) CCTA/FAO Symp. on Weed Control, Ibadan, 6 p. (Commonwealth Inst. Biol. Control, K.W. Neatby Bldg., Carline Avenue, Ottawa, Canada)

Brief reports are given of the present position with regard to the biological control of, among other weeds, Lantana camara, Opuntia spp., Salvinia auriculata, Eichhornia crassipes, Acanthospermum hispidum, Cordia macrostachus, Striga spp., Imperata cylindrica and Eupatorium odoratum. -Weed Abstr. 11(3),1962.

202. SIMMONDS, F.J.

1963. Biological control of pests in the tropics. Trop. Sci., 5(4):200-7. (Commonw. Inst. Biol. Control, Curepe, Trinidad)

The present status and potential of biological methods for the control of insect pests and weeds is discussed with reference to the role of specialized national and international organization is implementing biological control investigations. Accounts are included of work on the control of Opuntia spp., Cordia macrostachya, Lantana camara, Clidemia hirta, Eupatorium adenophorum and Eichhornia crassipes. -Weed Abstr. 15(5/6),1966.

203. SINGH, S.B.

1963. Preliminary experiments on the relative manurial values of some aquatic weeds as composts. Proc. Indo-Pac. Fisheries Counc., 10th Sess., Section 2, 141-5.

Experiments conducted by the central inland fisheries research substation, Cuttack, India, indicated that composts suitable for vegetable growing could be made from the following aquatic weeds: Pistia, Ottelia, Hydrilla, Najas and Eichhornia. Tables. 9 refs. - Trop. Abstr. 20(1),1965.

204. SINHA, S.N. and SINHA, L.P.

1969. Studies on use of water hyacinth culture in oxidation ponds treating digested sugar wastes and effluent of septic Tank. Environmental Health 11:197-207.

Experiments were conducted to evaluate the capacity of water hyacinth to purify and clear the digested sugar factory waste and septic tank effluents. It has been found that water hyacinth thrives well in digested sugar waste and also enhances the rate of biological oxidation of the wastes. Apart from this it (i) increases the oxidation-reduction potential (ii) coagulates and removes turbidity and (iii) removes odour. -Author

205. SIRCAR, S.M. and CHAKRAVERTY, R.

1962. The effect of gibberellic acid and growth substances of the root extract of water hyacinth (Eichhornia crassipes (Mart.) Solms) on rice and grain. Indian J. Pl. Physiol., 5(1/2):257-63, bibl. 17. (Dept. Botany, Univ. Calcutta, India)-Weed Abstr. 14(6), 1965.

206. SMOLKA, H.

1962. Trials on controlling water hyacinths (Eichhornia crassipes and E. azurea). An. 4° Seminario Brasileiro de Herbicidas e Ervas Daninhas, 73-74. (Por) (Rio Light S.A., Av. Marechal Floriano 168, Rio de Janeiro, Brazil)

Complete destruction of mats of water hyacinth infesting reservoirs containing water diverted from the Rio Paraiba do Sul was obtained when these were treated with 0.45% Bi-Hedonal (2,4-D 28.4% + MCPA 28.3%) + a wetter (0.05% Esapon) applied in 1250 l. spray/ha. Repeat application after 3-4 days was needed to ensure thorough penetration of the foliage. -Weed Abstr. 13(4),1964.

207. SOERJANI, M., SOETIDJO, D. and SOEMARWOTO, O.

1969. Weed problems in food crops in Indonesia. PANS, 15(3): 334-9. (Bibl. 13; Natn. Biol. Inst. Bogor, Indonesia)

Research in weeds and weed control in Indonesia is reviewed. Weeds of rice and sugar-cane are listed. Imperata cylindrica, an important weed, has a relatively high C : N ratio which could be used to increase the soil o.m. content and prevent erosion; the crops Psophocarpus palustris, Mimosa invisa and Gliricidia spp. can compete with it and a dipteran gall parasite Pachidiplosis sp. seems to have potential for its control. Chemical weed control in rice is still at the experimental stage; herbicides show good results but Cyperus rotundus was resistant. Eichhornia crassipes is a serious weed and covers most of the important waters in Indonesia. -Weed Abstr. 19(2),1970.

208. SPENCER, S.L.

1967. The effects of herbicides on seven species of aquatic plants in the Mobile Delta. Proc. 20th Stn. Weed Conf., 319-26. (Alabama Dept. Conserv., Montgomery)

Of the herbicides tested for the control of alligator-weed (Alternanthera philoxeroides) on plots frequently covered with water at high tide, best results were obtained with aminotriazole + ammonium thiocyanate (aminotriazole-T) 4#, fenoprop PGBE (propylene glycol butyl ether) ester 4#, Tordon (Picloram) 4# and fenoprop PGBE ester 12# + amino triazole-T 1#. None of the granular formulations tested gave satisfactory control of alligator-weed, though fenoprop at 30# provided temporary knock-down.

Excellent, long-term control of an infestation of Orontium aquaticum on the edge of an old natural pond was obtained with various liquid and granular formulations of fenoprop and 2,4-D. Above-water parts of Hydrochloa caroliniensis infesting the border of a farm pond were moderately well controlled by fenoprop PGBE ester 12#, aminotriazole-T 6# and diquat 1#, but only aminotriazole-T suppressed rapid reinfestation. Of the herbicides tested for the control of Vallisneria americana on the shoreline at Perdido Bay, granular formulations of fenoprop 20 and 30# and of sodium arsenite 15# were the most satisfactory.

In trials in ponds, excellent results were obtained against Eichhornia crassipes with diquat 2# and against Typha sp. using diquat and paraquat each at 1#. Glyceria sp. suffered initial knockback following treatment with diquat at 2# but regrew rapidly. Aminotriazole-T showed most promise for the control of Glyceria sp. but was unable to prevent complete regeneration within 12 months. -Weed Abstr. 18(2),1969.

209. STOVELL, F.R.

1966. The use of herbicides as invert emulsions for adequate weed control. Proc. 8th Br. Weed Control Conf., 600-4. (Bibl. 6, Shellstar Ltd., 70 Brompton Road, London S.W. 3., England).

The Bi-fluid system for applying invert emulsion sprays was evaluated against emergent species (a) in the Sudan, where infestations of Eichhornia crassipes on the upper reaches of the Nile were treated with 2,4-D, and (b) in one series of trials in England, where Phragmites communis, Typha latifolia and Sparganium ramosum were treated with dalapon Na. Compared with conventional sprays, invert emulsions produced by the Bi-fluid system appeared to effect a more rapid kill of emergent species at a significantly lower dosage rate.

The results are also discussed of preliminary, small-scale trials with 2,4-D oil-soluble amine formulated in a high-density oil to investigate the potential of invert emulsion sprays for the control of submerged species. -Weed Abstr. 16(4),1967.

210. SUNDRUM, N.V. and MEHTA, P.R.
1960. Control of water hyacinth with formulations of 2,4-D in Bharatpur (Rajasthan). Pl. Protect. Bull., 12(1-4):8-10, bibl. 4.

Spraying twice with 2,4-D amine at 2.5 a.e./ac killed water hyacinth (Eichhornia crassipes). -Field Crop Abstr. 18(2),1965.

211. SWAMY, B.G.L.
1966. The origin and oganization of the embryonic shoot apex in Eichhornia crassipes (Pontederiaceae). Bull. Torrey Bot. Club. 93(1):20-34. Illus.

The consensus of contemporary opinion holds that although the earlier stages of embryogenesis in both monocotyledons and dicotyledons follow identical sequences, the single cotyledon of the monocotyledon embryo develops from the terminal pole of the proembryo while the shoot apex originates from a lateral locus on the embryonal axis, which relationship is reversed in the dicotyledon embryo. In contrast, studies on the embryo development in Eichhornia crassipes, as also in some of the recently investigated monocotyledon taxa, clearly demonstrate that the topographical relationships of cotyledon-epicotyl and shoot apex-hypocotyl are the same as in the dicotyledon embryo. These results, therefore, seriously question the validity of current understanding of the monocotyledon embryo. The present study also throws further light on the occurence of diverse patterns of shoot apex organization in the monocotyledon embryos. While in some of the recently investigated taxa the cotyledonary and epicotylary loci share equal quanta of the working sphere of the shoot apex, in Eichhornia the cotyledonary locus involves three-quarters and the epicotylary locus one-quarter. A summation of results of recents researches on monocotyledon embryogenesis warrant fresh investigations which in turn would lead to formulation of concepts that are in keeping with observed facts. -Biol. Abstr. 47,1966.

212. TABITA, A. and WOODS, J.W.
1962. History of hyacinth (Eichhornia crassipes) control in Florida. Hyacinth Contr., J. (1):19-22, tabs. 1.
A review. -Weed Abstr. 14(6),1965.

213. TANGANYIKA, DEPARTMENT OF AGRICULTURE
1960. Rep. Dept. Agric. Tanganyika, (1961), I, 38 p.

Prickly pear (Opuntia sp.). The local people are giving more support to the campaign against prickly pear in East Labe by spreading the scale insect, Dactylopius tomentosus, and by burning clumps of the weed.

Eichhornia crassipes. Spraying of the Pangani and Sigi rivers with MCPA was repeated at least twice. Annual spraying is necessary owing to the rapid regeneration. -Weed Abstr. 11(5),1962.

214. TAYLOR, K.G. and ROBBINS, R.C.
1968. The amino acid composition of water hyacinth (Eichhornia crassipes) and its value as a protein supplement. Hyacinth Contr. J., (7):24-5. (Bibl. 14; Dept. Food Sci., Univ. Florida, Gainesville)

The following essential amino acids yielded by 40-h hydrolysis of 100 g water hyacinth protein (calculated at 16 g N/100 g crude protein) were determined by chromatography; methionnine 0.72 g, phenylalanine 4.72 g, threonine 4.32 g, lysine 5.34 g, isoleucine 4.32 g, valine 0.27 g and leucine 7.2 g. From a dietary standpoint, the results indicate that the lysine content of water hyacinth is sufficiently high to serve as an effective supplement to grain protein for animal or human consumption, though further work is required to determine the level of tryptophan, another limiting amino acid in grain. -Weed Abstr. 19(2),1970.

215. TILLEY, L.G.W.
1966. A method of water hyacinth control. Cane Grow. Q. Bull., 29(4):116.

From the results of trials on the control of Eichhornia crassipes in Queensland, the most promising treatment was 2,4-D amine + 0.5% wetter applied at 2.5# at the onset of the wet season when the plant is in vigorous growth just before flowering, followed by a second application at the same rate 3-4 weeks later. A power mist-blower was a more effective method of application than a boom sprayer. -Weed Abstr. 15(4),1966.

216. TIMMER, C.E. and WELDON, L.M.
1967. Evapotranspiration and pollution of water by water hyacinth. Hyacinth Contr. J., (6):34-7. (Bibl. 9; USDA, Fort Lauderdale, Florida)

In growth pool studies, water lost through evapotranspiration from water hyacinth (Eichhornia crassipes) was 3.7 times greater than the loss by evaporation, but the losses were reduced by an application of 2,4-D amine at 4# in 200 gal spray. A direct relationship was established between solar energy and water lost through evapotranspiration. Water analysis showed that the presence of E. crassipes increased turbidity (silica standard), tannin and lignin, and the depth of plant debris, compared to open water. -Weed Abstr. 17(5),1968.

217. UHLIG, S.K.
1967. A weed blocks the Nile. SYS Reptr. (4):12-14. (D; Inst. Forstbot, Tech. Univ. Dresden, Tharandt, E. Germany)

An account is given of the world distribution of water hyacinth (Eichhornia crassipes), possibilities for its control with chemicals and by biological means, and the particular problems it poses in the Sudan. The Hyacinth Control Committee was formed in the Sudan in

1958 to organize a programme for the control of infestations on the White Nile, which extend over a distance of 1400 km between Juba in the South and the Jebel Aulia dam in the North, and on its tributary, the Sobat river. Extensive use of 2,4-D amine is made for its control, though possible contamination of irrigation water restricts its use in the cotton-growing areas north of Malakal. Efforts are being made to contain the present infestations and in particular to prevent its spread to the main Nile and to the Blue Nile. -Weed Abstr. 17(5),1968.

218. UHLIG, S.K.

1968. Das Problem der Wasserhyazinthe, Eichhornia crassipes Solms. (The water hyacinth problem). Beitr. Trop. Subtrop. Landwirtsch. u. Tropenveterinärmed. 6(3): 221-9.

Because of its strong propagation the water hyacinth has become one of the most troublesome weeds of tropical and subtropical waters. In this literature review attention is paid to the botany and distribution of the plant, the infestation, and the mechanical, and biological control methods. Mechanical control, such as by dredging, is only of local importance. Commercial biological control methods have not been found as yet. Various herbicides, such as 2,4-D and MCPA have been used successfully, although it is only possible to reduce the infestation of the water hyacinth to a tolerable extent by several repeated applications. English, French and Spanish summaries. Photos. 46 refs. -Trop. Abstr. 24(6),1969.

219. ULTSCH, G.R.

1971. The relationship of dissolved carbon dioxide and oxygen to microhabitat selection in Pseudobranchus striatus. Copeia (2): 247-252. Illus.

Dissolved O_2 and CO_2 undergo daily cycles in the water hyacinth community inhabited by P. striatus (Amphibia, Sirenidae). Concentrations of both gases are uniform from the surface to the bottom at sunrise, as is the water temperature. A slight temperature gradient of 1-2°C develops during the day, accompanied by an increasing top to bottom differential in the concentrations of the dissolved gases. This differential becomes maximal during the warmest part of the day, and disappears by the next morning. O_2 peaks in the late afternoon, when CO_2 is at a minimum; O_2 is minimal at sunrise, when CO_2 is highest. At any given time, the O_2 concentration is lower under the hyacinths than it is in the open water and CO_2 is higher. Pseudobranchus can utilize purely aquatic respiration, or supplement this with air breathing. Analysis of field and experimental data suggests that supplemental air-breathing is required at least 50% of the day for the period studied. -Biol. Abstr. 52(19),1971.

220. VAN DONSELAAR, J.

1968. Water and marsh plants in the artificial Brokopondo Lake (Surinam, S. America) during the first three years of its existence. Acta Bot. Neerl., 17(3): 183-96. Bibl. 15; Inst. voor Systematische Plantkunde, Utrecht, Netherlands.

The Brokopondo Lake began to form in February 1964 when the dam in the Surinam River near Afobaka was closed. The basin largely occupied by forest was not cleared beforehand. During the first three years, the lake attained an area of 84,000 ha with a maximal

depth of 38 m and the aquatic species Eichhornia crassipes, Ceratopteris pteridoides, C. deltoidea, Lemna valdiviana, Spirodela biperforata, Utricularia gibba, U. hydrocarpa and Jussiaea natans became numerous. By April 1966 when the lake covered about 78,000 ha, E. crassipes and C. pteridoides had colonized 53 and 21% respectively, of this area. Since September 1966, both species have diminished greatly, E. crassipes as a result of aerial applications of 2,4-D and C. pteridoides for unknown reasons.

Floating pieces of decaying wood became overgrown by a variety of plant species 27 of which were recorded. Mixed vegetations of water and marsh plants developed, which included free-floating mats (E. crassipes being the matrix), patches attached to partly submerged tree tops, and belts along the shore. Twenty-two species were observed as constituents of these floating vegetations. -Weed Abstr. 18(3),1969.

221. VAN REGTEREN ALTENA, C.O.

1968. Transport of Ancylidae (Gastropoda) by a water-beetle in Surinam. Basteria 32(1-3): 1.

A water-beetle carrying 6 Ancylidae on its elytra was found in a water hyacinth (Eichhornia crassipes (Mart.) Solms) in the Coropina Creek near Bersaba, Suriname District, Surinam, on March 9, 1947. The snails were tentatively identified as Anisancylus obliquus (Broderip and Sowerby). The beetle was identified as Megadytes laevigatus Olivier. The case may be added to those listed by Rees (1965) under the heading Records of fresh-water Limpets of the family Ancylidae found on the elytra of aquatic beetles and Hemiptera. -Biol. Abstr. 51,1970.

222. VERMA, I.S.

1967. Chemicals for weed control. Pesticides, Bombay, 1(4): 13-18. (Nat. Org. Chem. Ind. Ltd. (for Shell Chem.) Bombay, India)

Types and formulations of herbicides are reviewed. In wheat, 2,4-D amine 0.8 kg or 2,4-D ethyl ester 0.6 kg/ha are applied at the 5-leaf stage. In sugar-cane, simazine at 4.4 kg pre-em. followed by 2,4-D amine or ester 1 kg a.e./ha post-em. have proved effective against Cyperus rotundus, a serious problem in the north. In Maharashtra, 2,4-D ethyl ester at 1 kg a.e./ha pre-em., repeated 30 days after germination, gave excellent control of most weeds. In rice, 2,4-D amine and MCPA at 2 kg a.e./ha are effective against dicotyledons, and propanil 4-6 kg a.e./ha, applied twice in rice at 2 and 4 weeks old, has proved effective against monocotyledons. Prefix (chlorthiamid) at 2 kg/ha has also given good results in paddy, applied 7-10 days after transplanting. In maize, 2,4-D amine at 1 kg a.e. (post-em.) and simazine 2.5 kg a.e./ha pre-em. (against grasses) are used. In sorghum and bajra (Pennisetum tryphoideum), Striga sp. is the most important weed and emerges soon after the crop. A single application of 2,4-D ethyl ester at 1.2 kg a.e./ha, applied in crops 4 weeks old, gives very effective control. 2,4-D ethyl ester at 6 kg a.e./ha, applied in a high spray volume and in the hot months of May-June, followed by spot treatment in September-October, has proved very effective against Eichhornia crassipes, eradicating it in 2 years. -Weed Abstr. 18(2),1969.

223. VOGEL, E. and OLIVER, A.D.
1969. Evaluation of Arzama densa as an aid in the control of water-hyacinth in Louisiana. J. Econ. Ent., 62(1):142-5. (Bibl. 5; Dept. Entomol., Louisiana State Univ., Baton Rouge 70803)

In S. Louisiana, larvae of the noctuid A. densa were found to feed on water hyacinth (Eichhornia crassipes), causing some plants to die and preventing development of seed heads on others. Young larvae feed on the epidermis of leaves, stems and crown. Older larvae bore into the crowns, stolons and leaf petioles. Feeding on the apical bud caused loss of apical dominance and the subsequent development of excessive numbers of lateral buds. In mixed stands of E. crassipes and Pontederia cordata both species were attacked by the larvae. Because A. densa larvae are stem and root borers with semi-aquatic adaptations and have no cultivated host, the species may be used successfully as an aid to E. crassipes control though the reduction of biotic factors which limit field populations and the development of mass rearing methods would increase its potential. -Weed Abstr. 19(2),1970.

224. VOGEL, E. and OLIVER, A.D.
1969. Life history and some factors affecting the population of Arzama densa in Louisiana. Ann. Entomol. Soc. Amer., 62(4): 749-52.

A noctuid moth, Arzama densa Walker, occurs commonly in southern Louisiana where its larva feeds on water hyacinth, Eichhornia crassipes Solms., and pickerelweed, Pontederia cordata L. It has at least 2 generations each year in this area. An average of 66.5 days is required for development of 1 generation under controlled laboratory conditions of 21°C and 14-hr photoperiod. Each female moth lays an average of 328 eggs in masses of 30-40 eggs. An average of 8.25% of the eggs are infertile. The incubation period is about 6 days. There are 6 or 7 larval stages in the life cycle. The larvae have large dorsocaudal spiracles in the 8th segment which enable them to feed below the water line. Some 6th instars undergo diapause which lasts from 25 to 120 days during fall and winter. Parasites and predators of eggs, larvae, and pupae significantly reduce field populations of the moth. -Biol. Abstr. 51,1970.

225. VYAS, S.R. and MOOLANI, M.K.
1966. Biological control of weeds. Proc. 2nd Weed Control Seminar..., organised by Dept. Agron., Punjab Agric. Univ., Hissar, 32-3. (Punjab Agric. Univ., Hissar, India)

The possibilities of controlling biologically Acanthospermum hispidum, Heliotropium europaeum, Myricafava and Stachytarpheta jamaicensis and of using the snail Marisa sp. to control Eichhornia crassipes, Nymphaea ampla, Ceratophyllum demersum, Potamogeton illinoensis and Najas guadalupensis are noted. -Weed Abstr. 18(1), 1969.

226. WAKEFIELD, J.W.
1962. Effects of water pollution on aquatic vegetation. Hyacinth Contr. J., (1):12, bibl. 1.

The results are given of an investigation on the effect of water pollution on aquatic vegetation in Florida. Domestic sewage and certain industrial wastes were found to promote the growth of

water hyacinth (Eichhornia crassipes), Bermuda grass (Cynodon dactylon), alligator weed (Alternanthera philoxeroides), pickerel weed (Pontederia cordata), salvinia (Salvinia sp.), duckweed (Lemna sp.) and unicellular algae, while excessive foaming of synthetic detergents produced chlorotic symptoms and inhibited the growth of E. crassipes.

Heavy metal ions, particularly copper and arsenic salts, petroleum products and heavy oils and hydrogen sulphide killed mixed vegetation in receiving waters, while effluent from a fluoride-processing plant completely eliminated all vegetation (including Vallisneria sp.), with the exception of one species of algae.

Preliminary results of studies on the effect of cooling water discharge from generating stations on vegetation indicate that Elodea sp., Potamogeton sp. and blue-green algae will tolerate water temperatures of slightly over 100°F for at least brief periods. -Weed Abstr. 14(6),1965.

227. WALLS, F.

1963. Diquat-a new contact weedkiller. Agric. Gaz., N.S.W., 73(12):647-9, figs. 1.

The properties and uses of diquat are reviewed briefly. Diquat has given promising results against Asphodelus fistulosus, Opuntia sp. and for controlling Azolla, Eichhornia crassipes and Salvinia sp. in ponds. -Weed Abstr. 12(5),1963.

228. WARNIMONT, F.J.

1965. The water hyacinth (Eichhornia crassipes) problem in the Congo catchment area. (Typescript) (Direction du Service des Voies navigables de la République Démocratique du Congo). Leopoldville, 22 p. (F; United Nations Adviser on Waterways)

The author reviews the introduction and spread of water hyacinth in the Congo and the important chemical control measures (with 2,4-D) undertaken during the period 1955-8. In spite of the good control obtained with herbicides complete eradication is unlikely to be achieved owing to the wide dissemination of plants during periods of high water. It is estimated that a new eradication campaign would cost > 1000 million Belgian francs, and would require some 1000-1500 trained persons in the field for at least five years. If it succeeded annual expenditure subsequently would be about 75 million Belgian francs per year. Meanwhile, further spread of water hyacinth upstream should be prevented by creating buffer zones at Stanleyville and Port Francqui. Infestation of Lake Tumba must be prevented. The Itimbiri and Mongala tributaries should be cleared. Permanent control teams are required in infested areas, where the main hazards caused by the plant are those to navigation. A map shows the extent of infestation. -Weed Abstr. 17(6),1968.

229. WELDON, L.W. and BLACKBURN, R.D.

1962. Identification of common aquatic weeds. Hyacinth Contr. J., (1):32-7, figs. 31, bibl. 6. (US Dept. Agric., Plant. Field Lab., Fort Lauderdale, Florida)

Photographic illustrations, with brief notes, are given for the identification of Eichhornia crassipes, Pistia stratiotes, Lemna sp., Alternanthera philoxeroides, Nuphar advena, Panicum hemitomon, P. repens, Pithophora sp., Najas guadalupensis and Elodea densa. -Weed Abstr. 14(6),1965.

230. WELDON, L.W. and BLACKBURN, R.D.

1966. Use of invert emulsion formulations in aquatic weed control. Hyacinth Contr. J., 5:12-14. (Bibl. 10; Crops Res. Div., Agric. Res. Serv., US Dept. Agric., Fort Lauderdale, Florida)

In trials in 1964 and '65 invert emulsions and conventional sprays of various 2,4-D formulations at up to 4# applied by helicopter appeared comparable in effect against water hyacinth (Eichhornia crassipes), though with invert emulsions uniform spray distribution was essential. Alligator weed (Alternanthera philoxeroides) was more susceptible to silvex (fenoprop) at 8# than to similar rates of 2,4-D, but showed similar response to invert emulsion and conventional spray applications. The Bi-fluid system of producing invert emulsions (see Weed Abstr.12:601) where unmixed oil and water fractions are delivered to common nozzles, proved a more effective means of application than did premixed water-in-oil emulsions applied by a spinning disk. -Weed Abstr. 16(4),1967.

231. WELDON, L.W. and BLACKBURN, R.D.

1967. The control of floating aquatic weeds with ametryne. Proc. 20th Stn. Weed Conf., 312-18. (Bibl. 4; USDA, Fort Lauderdale, Florida)

In trials carried out in the glasshouse, growth pools and under field conditions, ametryne appeared effective against water hyacinth (Eichhornia crassipes) at 3# but was variable in effect at lower doses. Alligator weed (Alternanthera philoxeroides) responded to ametryne when applied in mixture with 2,4-D or fenoprop but not when applied alone. Ametryne residues persisted for prolonged periods in growth pools, but a dose of 4# applied to a non-flowing canal for the control of E. crassipes disappeared within 24 h. - Weed Abstr. 18(2),1969.

232. WELDON, L.W., BLACKBURN, R.D. and SEAMAN, D.E.

1961. Recent advances in aquatic weed control. Proc. Soil Crop Sci. Soc. Fla, 21, 1961:107-14, bibl. 16, illus.

Diquat applied at 5 ppm. to a canal in which the water flow was stopped for several days, gave a complete kill in 3 weeks, and prevented re-growth, for at least 4 months, of Najas guadalupensis, Ceratophyllum demersum, Salvinia rotundifolia, duckweed (Lemna spp.) and an alga (Pithophora). Diquat at 3 lb/ac gave 97% control of Pistia stratiotes in drainage ditches after 3 weeks; complete control would probably have required retreatment. One application of amitrole-T at 1-2 lb/ac can give 90-100% control of Eichhornia crassipes. Alternanthera philoxeroides is readily controlled by granular silvex at 20-40 lb/ac when the weed is rooted in soil, but floating mats require repeated application at 8 lb/ac. -Field Crop Abstr. 16(3),1963.

233. WHITE, A.C.

1963. Diquat and paraquat synopsis of aquatic weed experiments. Proc. 16th Southern Weed Conf. 1963: 357-64, bibl. 3. (Ortho Div., California Chem. Co., Orlando, Florida)

The chemical and physical properties, toxicity and mode of action of diquat and paraquat are briefly reviewed, and a summary is given of the results of various trials on the control of Alternanthera philoxeroides, Chara spp., Lemna minor, Spirodela spp.,

Wolffia spp., Pithophora spp., Myriophyllum spp., Potomogeton spp., Heteranthera dubia, Salvinia rotundifolia, Eichhornia crassipes, Pistia stratiotes, Elodea densa and E. canadensis with both paraquat and diquat, and of Ceratophyllum demersum, Najas guadalupensis and Ruppia spp. with diquat. Diquat and/or paraquat have also shown promise in controlling Utricularia spp., Hydrochloa caroliniensis, Scirpus eriophorum, Hydrodictyon sp., Bacopa rotundifolia, Ranunculus spp., Sagittaria latifolia, Spirogyra spp. and Panicum repens. -Weed Absr. 12(6),1963.

234. WHITE, A.C.

1965. Status report on diquat and paraquat as aquatic herbicides. Hyacinth Contr. J., 4:18-19. (Bibl. 4; Chevron Chem. Co., Orlando, Florida)

The results of several years testing indicated that diquat and paraquat gave equal control of floating weeds such as Pistia stratiotes and Salvinia rotundifolia, but diquat gave better control of Lemna spp. and Eichhornia crassipes. For submersed weeds, diquat gave consistent control of Najas guadalupensis, Ceratophyllum demersum, Utricularia spp., Elodea canadensis, Potamogeton spp., Myriophyllum spp., and Hydrocotyle umbellata and showed promise against Scirpus spp., Sparganium spp., Limnobium spongia, Eleocharis spp., Ranunculus spp., Nasturtium officinale, Wolffia columbiana, Jussiaea spp. and Heteranthera dubia. Paraquat however gave markedly superior control of Hydrochloa sp., Alternanthera philoxeroides, Panicum repens and P. hemitomon. In general, diquat and paraquat gave similar control of most susceptible submerged weeds while paraquat gave better control of the rooted emergent weeds. In several trials, however, paraquat persisted twice as long as diquat in treated waters and was more toxic to fish. -Weed Abstr. 16(1), 1967.

235. WILD, H.

1956. Water hyacinth (Eichhornia crassipes Mart. Solms.) in Southern Rhodesia. Proc. 2nd Symp. Afr. Hydrobiol. Inland Fish., 1956, (C.S.A.S.S. Publ. 25), 127-29, bibl. 1.

This is a short account of the introduction into, and distribution of, E. crassipes in Southern Rhodesia and of the progress of the Government's eradication campaign. Future prospects for its control are discussed. -Weed Abstr. 11(6),1962.

236. WILD, H. and MITCHELL, D.S.

1970. The effect of Bayluscide on the waterfern Salvinia auriculata and other water plants. Pflanzenschutz Nachrichten "Bayer" 23(2):112-7.

In Rhodesia, it was observed that the molluscide niclosamide, used in the control of snails in water, affected Salvinia auriculata at a concentration of 0.5 ppm. Experiments showed that niclosamide at concentrations of 2-5 ppm gave complete control of S. auriculata 2 weeks after spraying. Niclosamide at concentrations of 0.5 and 1 ppm gave approx. 50% control. Niclosamide damaged the buds, and abnormal leaves were developed, after which the plants died. The alga Chara sp. was controlled also after application of niclosamide at concentrations of 0.5 ppm and higher. Other water plants affected, but not fully controlled, were Lemna spp. and Eichhornia crassipes. -Trop. Abstr. 26(7),1971.

237. WILSON, C.L.

1969. Use of plant pathogens in weed control. Ann. Rev. Phytopath., 7:411-34. (Bibl. 145; Univ. Arkansas, Fayetteville, Arkansas)

It is suggested that the use of effective plant pathogens for the control of weeds would have certain advantages over chemical herbicides in that (a) they can be species specific, (b) residue and toxicity problems would be reduced or eliminated and (c) there would be no accumulation of the herbicide in soil and underground water. Current research projects are reviewed together with the literature concerning the successful biological control of Opuntia spp., Arceuthobium spp., Myriophyllum spicatum, Eichhornia crassipes, Diospyros virginiana, Cuscuta spp. and Xanthium spinosum. Other aspects considered include the diseases of miscellaneous weeds, ecological interaction of weeds and plant pathogens, interactions of plant pathogens in chemical weed control and genetic considerations. -Weed Abstr. 19(5),1970.

238. WILSON, F.

1967. The role of aquatic weeds in mosquito control. Hyacinth Contr. J., (6):26-7.

The eradication of aquatic vegetation is advocated as a means of discouraging fresh water mosquito production, by creating open conditions to promote the build-up of mosquito-feeding minnows and to encourage wave or ripple action on the water surface. Larvae of three species of the genus Mansonia, which obtain oxygen by inserting their siphons into submersed roots of emergent weeds, are controlled by eradicating the host plants, water lettuce (Pistia stratiotes) in the case of two species, and a wide range of plants, including P. stratiotes, blue flag (?), arrowhead (Sagittaria sp.), cattails (Typha spp.), water hyacinth (Eichhornia crassipes) and willows (Salix spp.), in the case of the third species. -Weed Abstr. 17(5), 1968.

239. WOODS, J.W.

1963. Aerial application of herbicides as used by the Game and Fresh Water Fish Commission. Hyacinth Contr. J., (2):20, bibl. 2.

Types of aircraft used by the Florida Game and Fresh Water Fish Commission for controlling water hyacinth (Eichhornia crassipes) with 2,4-D are briefly described. The PA-25 Piper Pawnee is currently used by the Commission for applying either spray or granular materials. For liquid application, herbicide in diesel oil is sprayed at 5 gal/ac in a 40-ft swath from an aircraft flying at a speed of 75 m.p.h. approximately 6 to 7 ft above the vegetation. For granular applications, provision is made for a hopper which will hold up to 600 lb of granular material. Flying at treetop level, granules are distributed in a 70-ft swath at rates between 100 and 350# .- Weed Abstr. 15(1),1966.

240. WOODS, J.W.

1965. Aquatic weed research. Recreation, boating, fishing and swimming. Proc. 18th Stn. Weed Control Conf., 488-9.

A survey carried out in 1964 in Florida shows that, apart from extensive areas of saw grass (Cladium jamaicense) in the

Everglades, 166,000 ac of fresh water are infested with weeds, predominantly Eichhornia crassipes, Pistia stratiotes, Elodea densa, Najus guadalupensis, Panicum hemitomon, Alternanthera philoxeroides, Nuphar advena and Typha latifolia. Their control with chemicals and by mechanical means is briefly discussed.

241. WUNDERLICH, W.E.
1962. History of water hyacinth control in Louisiana. Hyacinth Contr. J., (1):14-16.
Water hyacinth (Eichhornia crassipes) was introduced in New Orleans as a horticultural exhibit in 1884 and became a serious problem in several regions of Louisiana within 10 years. The clearance and maintenance of waterways has been undertaken largely by the US Army Engineers, using pulverizing and cutting equipment and chemicals, but in 1958 the US Army Engineers and the State Authorities began a five-year programme for the control of E. crassipes on a cost-sharing basis.
Sodium arsenite was successfully used against E. crassipes for 35 years, but produced toxic side-effects and was finally abandoned in 1937. Since its introduction, 2,4-D has given excellent kill of E. crassipes at concentrations non-toxic to humans or fish. -Weed Abstr. 14(6),1965.

242. WUNDERLICH, W.E.
1964. Water hyacinth control in Louisiana. Hyacinth Contr. J., (3):4-7.
A review. See Weed Abstr. 14:1830. -Weed Abstr. 15(2),1966.

243. YOUNG, H.E.
1967. Water hyacinth. Cane Grow Q. Bull., 30(3): 98-101. (Bureau of Sugar Exp. Stns., 99 Gregory Terrace, Brisbane, Queensland, Australia)
2,4-D amine or 2,4-D low volatile ester at 2-4 lb a.i. in up to 100 gal water/ac + 0.5% wetter, applied in the warmer months, is very effective against Eichhornia crassipes. The low rate effects a good kill and the high rate results in a fairly rapid sinking of the mat of weed. Retreatment is usually required 4-8 weeks later to kill surviving plants and new seedlings. Amine forms of 2,4-D and water based sprays are less toxic to fish than the esters and oilbased sprays. -Weed Abstr. 17(1),1968.

244. ZEIGER, C.F.
1962. Hyacinth obstruction to navigation. Hyacinth Contr. J., 16-17.
The colonization and spread of water hyacinth (Eichhornia crassipes) on waterways in Florida are briefly reviewed, together with methods used by the US Army Engineers for its control. -Weed Abstr. 14(6),1965.

245. ZEIGER, C.F.
1963. Field experiments with silvex and amitrole-T for aquatic weed control. Hyacinth Contr. J., (2): 6-12, figs. 23. (US Army Engineers District, Jacksonville, Florida)
Visual appraisal of the effect of fenoprop propylene glycol butyl ether ester on alligator weed (Alternanthera philoxeroides)

and of 2,4-D and amitrole-T + fenac on water hyacinth (Eichhornia crassipes) is provided by photographs taken before treatment and 30 and 60 days after treatment at various locations in the U.S.A. -Weed Abstr. 15(1),1966.

246. ZEIGER, C.F.

1967. Biological Control of Alligator weed with Agasicles n. sp. in Florida. Proc. Southern Weed Conf., 20:299-303.

Alligator weed (Alternanthera philoxeroides) is a serious explosive weed in Florida, clogging canals and drainage ditches and sometimes breaking free to float into navigable waters. Apparently useless, the hollow stems with rooted nodes form a dense mat. A search was made for predators in South America where the plant is indigenous and tests were made on a flea beetle in the genus Agasides as a possible biological control agent.

In field surveys and laboratory tests, Agasides sp. was found unable to complete its life cycle on any plant except its normal host, alligator weed. The beetle would not feed on species of Polygonaceae, Chenopodiaceae, sugarbeet, rice, cotton etc.

After State and Federal approval in March 1964, batches of flea beetles were released at sites in South Carolina, California, Mississippi and Florida. Within 35 days of release there were fresh hatchings of beetles: beetles were able to fly for long distances. Results showed widespread destruction of alligator weed in March, April and May During June, July and August beetles were inactive but webworms (Herpetogramma bipumetalis) and Hymenia fascialis were quite active in control. Activity of beetle recommenced in October and continued until May although beetles sought shelter in the bankside vegetation, which they did not feed on, during periods of frost. Populations of beetles have continued to increase with an absence of predators. -A.H.

247. ZEIGER, C.F.

1967. Objectives and limitations of various agencies in aquatic weed control. Hyacinth Contr. J., (6):26. (U.S. Army Engr. Dist., Jacksonville, Florida)

A note is given on the association between the US Crops Engineers and local, State and Federal agencies in the maintenance of navigable waterways. Herbicide research is conducted for the Corps of Engineers by the US Department of Agriculture at Fort Lauderdale, Florida, and on biological control of aquatic weeds in South America and California. A co-operative programme with the Florida Game and Fresh Water Fish Commission since 1960 has produced very good results in the control of water hyacinth (Eichhornia crassipes). -Weed Abstr. 17(5),1968.

SUBJECT INDEX

Printed at the Applied Scientific Research Corporation of Thailand Press
196 Phahonyothin Road, Bang Khen, Bangkok 9, Thailand
by Mr. Siri Nandhasri B.E. 2517