

Terrestrial Plants Molluscicidal to Lymnaeid Hosts of Fascioliasis Hepatica in Puerto Rico¹

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ABSTRACT

Molluscicidal assay of 200 Puerto Rican plants revealed 30 to be active against *Lymnaea cubensis* and *L. columella* under laboratory screening. Among these 30, 16 were notably toxic against lymnaeids, killing all snails in the range of 25 to 200 p/m. Of plant parts tested, including seeds, roots, fruits and leaves, the latter two proved most uniformly toxic. Only in the case of *Solanum nodiflorum* were all parts toxic. This paper discusses how molluscicidal plants may be beneficially used in the field to control snail-borne diseases, and what qualities an ideal molluscicidal plant should have.

INTRODUCTION

Extensive literature attests to the great efforts made to control fascioliasis since its European discovery in 1379. It continues as a major agricultural problem adversely affecting ovine and bovine productivity. Man is an occasional victim of *Fasciola hepatica* in some 20 countries; it is a serious public health problem in Perú (1).

Factors in the control of fascioliasis are health education, and hygiene, improved farm management, developments in chemotherapy, vaccination, and destruction of snail intermediate hosts. Our interest is the possible use of molluscicidal plants for controlling the Puerto Rican snail vectors *Lymnaea columella* and *L. cubensis*.

Although much progress has been made in chemical poisoning of snail vectors of the major human trematodiasis, such as in schistosomiasis, methods provided do not fit the requirements of fascioliasis control. Among several problems, there is the possibility of harming agricultural herbs or crops through dispersion of toxic chemicals. Since the snail vectors are commonly amphibious, their pattern of dispersal is extensive and poorly defined, making it difficult to expose all to molluscicides. Alternatively, we seek new solutions to an ancient problem under the aegis of biological control of the snail vectors. Naturalistic methods for killing snails are varied (2, 7, 13) and provide many research leads. In Puerto Rico, a number of studies indicate promise of success. *Marisa*, a demonstrated predator of other fresh water snails, apparently destroyed colonies of *Lymnaea columella*, as well as *Biomphalaria glabrata* (16). The same was indicated in a laboratory study (4) against *L. caillaudi*

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(the African vector of fascioliasis *gigantica*). *Marisa* is used routinely by the Puerto Rico Department of Health for suppressing populations of *B. glabrata* in control of schistosomiasis (15, 17). Berg and co-workers have clearly shown that the specific predation of freshwater snails by hundreds of species of sciomyzid marsh-fly larvae is worthy of definitive field trials in trematode control (2). Studies are in progress using the native *Sepedon caerulea*, for the purpose of controlling our lymnaeid vectors of fascioliasis (5). The aquatic annelid *Chaetogaster limnaei* has been shown to destroy snails and their eggs, cercaria, and miracidia of *Fasciola hepatica* (1). Preliminary tests of the ability of this predatory annelid to control lymnaeids are in progress.³ Paralleling the above efforts, we sought yet another means of bringing abating pressure to bear upon *Lymnaea* utilizing toxic materials inherent in local land plants.

The literature in this little known field has been reviewed by Bond (3). It reflects empirical studies of many plant materials, for example, the saponins (14). The hope that an effective plant molluscicide derived from Endod (*Phytolacca dodecandra*) could be employed to control schistosomiasis in Ethiopia has received well deserved notice (9). In that program Endod powder is mass produced for ordinary application in endemic bodies of water. Our ultimate intention is to search out those plants that have useful molluscicidal properties against *Lymnaea* and to grow the toxic vegetation in or at the margins of snail habitats. Leaf or fruit might provide toxic transport in some cases, while root exudates might suffice in others. This study was a survey to find molluscicidal plants that may be used in this manner as biological control against the snail vectors of fascioliasis hepatica.

MATERIALS AND METHODS

Two hundred plants listed in tables 1 and 2 were collected in the northern part of Puerto Rico; two test plants were from the Dominican Republic. The criteria used for the selection of the plants were 1) genera of plants known to be toxic against snails; 2) plants known to have medicinal effects in mammals; 3) plants toxic for mammals; and 4) randomly selected plants from lymnaeid habitats.

Lymnaea cubensis and *L. columella* were the two snail species used in this work. These snails were reared under standard laboratory conditions. *L. cubensis* was cultured in a mud tray nurtured on an algal overgrowth. *L. columella* was reared in aquaria with water two in deep. A supplementary food formula consisting of alfalfa powder, wheatgerm, Dog Chow, powdered milk (4:2:2:1) and calcium chloride (3.8% of total volume) was also provided for both species.

³ P. Bendezú, personal communication, 1974.

TABLE 1.—*Molluscicidal plants-lethal concentrations (100%)*

Family name	Genus and species	Common names	Toxic parts ¹	P/m
Alpinaceae	<i>Hedychium coronarium</i> ²	Nardo, Jazmín del río	Seeds	25
Apocynaceae	<i>Allamanda cathartica</i> ²	Canario	Leaves	1000
Asclepidaceae	<i>Asclepias curassavica</i>	Algodoncillo	Roots	100
Araliaceae	<i>Polyscias guilfoylei</i> ²	Areliá	Leaves and Stem	100 and 200
Burseraceae	<i>Bursera simaruba</i>	Almácigo	Seeds	1000
Basidiomycetae	<i>Unidentified Basidiomycete</i>	Unknown	All Parts	1000
Casuarinaceae	<i>Casuarina equisetifolia</i>	Pino	Fruits and Leaves	100 and 1000
Dioscoreaceae	<i>Dioscorea rotundata</i>	Ñame blanco	Leaves	1000
Euphorbiaceae	<i>Codiaeum variegatum</i>	Crotón	Leaves	1000
	<i>Jatropha gossypifolium</i>	Tuatúa	Leaves	1000
Fabaceae	<i>Andira inermis</i>	Moca	Roots	1000
	<i>Cajanus cajan</i>	Gandul	Roots and Leaves	1000
	<i>Indigofera suffruticosa</i>	Añil	Seeds	100
Mimosaceae	<i>Inga vera</i>	Guava	Roots and bulbs	1000
	<i>Samanea saman</i> ²	Samán	Leaves	1000
Onagraceae	<i>Ludwigia angustifolia</i>	Hicotea	Leaves	1000
Phytolaccaceae	<i>Phytolacca rivinoides</i> ³	Tinta, Juan de Vargas	Mature Fruits	200
	<i>Phytolacca isocandra</i>	Bella Sombra	Mature Fruits	200
Rubiaceae	<i>Duggenia hirsuta</i> ²	Mata de mariposa	Fruits	100
	<i>Genipa americana</i> ²	Jagua	Fruits (immature)	1000
Solanaceae	<i>Capsicum frutescens</i>	Ají	Leaves and Fruits	100
	<i>Cestrum diurnum</i>	Dama del día	Leaves and Mature Fruits	1000
	<i>Cestrum laurifolium</i>	Galán del monte	Leaves and Mature Fruits	100
	<i>Cestrum macrophyllum</i> ⁴	Galán del monte	Leaves	100
	<i>Lycopersicon esculentum</i>	Tomate	Leaves	1000
	<i>Solanum nodiflorum</i>	Yerba mora	All Parts	100
	<i>Solanum torvum</i>	Berenjena cimarrona	Leaves	1000
	<i>Solanum mammosum</i>	Berenjena de cucaracha	Mature Fruits (Pulp)	100
Verbenaceae	<i>Clerodendron fragrans</i> ²	Flor de muerto	Leaves	1000

¹ Roots, leaves and fruits of all plants were tested separately with the exception of those marked with ² and ⁴ footnotes.² Roots not tested.³ Collected in Dominican Republic at 3,000 feet above sea level and in Puerto Rico at El Verde.⁴ Only leaves tested.

TABLE 2.—*Non-molluscicidal plants*

Family name	Genus and species	Common name
Acanthaceae	<i>Crossandra infundibuliformis</i>	Doña Juana
	<i>Justicia verticillata</i>	Unknown
	<i>Ruellia equisetiformis</i>	Lluvia de coral
	<i>Stethoma pectoralis</i>	Curia
Alpinaceae	<i>Alpinia purpurata</i>	Purple Ginger
	<i>Alpinia speciosa</i>	Shell flower
Alismaceae	<i>Sagittaria lancifolia</i>	Saeta de agua
Amaranthaceae	<i>Amaranthus paniculata</i>	Unknown
	<i>Achyranthes aspera</i>	Unknown
	<i>Petiveria alliacea</i>	Anamú
Amarilidaceae	<i>Agave angustifolia</i>	Agave
	<i>Agave furcroides</i>	Henequén
Amilaceae	<i>Centella asiatica</i>	Yerba de chavos
Anacardiaceae	<i>Mangifera indica</i>	Mango
Annonaceae	<i>Annona glabra</i>	Corazón cimarrón
	<i>Annona muricata</i>	Guanábana
Apocinaeae	<i>Nerium oleander</i>	Alelí
Araceae	<i>Dieffenbachia seguine</i>	Rábano
	<i>Philodendron dubius</i>	Yautia type
	<i>Syngonium podophyllum</i>	Unknown
Araliaceae	<i>Aralia balfouriana</i>	Areliá
Asclepidaceae	<i>Cryptostegia grandiflora</i>	Bejuco de goma
Balsaminaceae	<i>Impatiens balsamina</i>	Espuela de galán
	<i>Impatiens sultani</i>	Miramelinda
Begoniaceae	<i>Begonia</i> sp.	Begonia
Bignoniaceae	<i>Crescentia cujete</i>	Higüero
Bixiaceae	<i>Bixia orellana</i>	Achiote
Boraginaceae	<i>Heliotropium indicum</i>	Cotorrera
Boraginaceae	<i>Tournefortia hirsutissima</i>	Nigua
Bromeliaceae	<i>Bromelia pyramidalis</i>	Bromelia
	<i>Bromelia</i> sp.	Bromelia
Cactaceae	<i>Hylocereus trigonus</i>	Pitahaya
	<i>Cactus</i> sp.	Ornamental cactus
Cambretaceae	<i>Bucida buceras</i>	Ucar
Cannaceae	<i>Canna</i> sp.	Maraca
Cesalpinaceae	<i>Biancaea septaria</i>	Zarza
	<i>Cassia occidentalis</i>	Hedionda
	<i>Cassia mimosioides</i>	Moriviví falso
	<i>Cassia siamea</i>	Casia
	<i>Cassia tora</i>	Hedionda
	<i>Tamarindus indicus</i>	Tamarindo
Characeae	<i>Chara</i> sp.	Chara
Commelinaceae	<i>Commelina virginiana</i>	Cohitre
	<i>Rhoeo discolor</i>	Sangría
Compositae	<i>Bidens pilosa</i>	Margarita silvestre
	<i>Calendula erecta</i>	Caléndula
	<i>Mikania cordifolia</i>	Guaco
	<i>Mikania fragilis</i>	Unknown
	<i>Parthenium hysterophorum</i>	Ajenjo cimarrón
	<i>Pluchea odorata</i>	Salvia
	<i>Pseudoelephantopus spicatus</i>	Lengua de vaca
	<i>Wedelia trilobata</i>	Manzanilla de playa

TABLE 2.—Continued

Family name	Genus and species	Common name	
Convolvulaceae	<i>Ipomoea rosea</i>	Bejuco de puerco	
	<i>Ipomoea tiliacea</i>	Bejuco de puerco	
	<i>Ipomoea triloba</i>	Bejuco de puerco, bejuquillo	
Crasulaceae	<i>Bryophyllum pinnatum</i>	Bruja	
	<i>Crassula</i> sp.	Unknown	
Cucurbitaceae	<i>Cayaponia americana</i>	Bejuco de torero	
	<i>Mormodica charantia</i>	Cundeamor	
Cyperaceae	<i>Cupania americana</i>	Guará blanca	
	<i>Cyperus alternifolius</i>	Paraguíta	
	<i>Cyperus giganteus</i>	Junco de ciénaga	
	<i>Eleocharis interstincta</i>	Junco de aparejos	
Dioscoreaceae	<i>Dioscorea aculeata</i>	Ñame tongo	
	<i>Rajania cordata</i>	Guayaro	
Eretiaceae	<i>Bourreria succulenta</i>	Palo de vaca	
	<i>Cordia corymbosa</i>	Capa	
Euphorbiaceae	<i>Alcalypha hispida</i>	Hot pocker	
	<i>Hura crepitans</i>	Molinillo	
	<i>Jatropha curca</i>	Piñón, tártago	
	<i>Jatropha grandifolia</i>	Tobillo	
	<i>Manihot esculenta</i>	Yuca	
	<i>Phyllanthus acidus</i>	Grosella	
	<i>Phyllanthus niruri</i>	Viernes Santo	
	<i>Phyllanthus nobilis</i>	Avispillo	
	<i>Poinsettia pulcherrima</i>	Flor de pascua	
	<i>Ricinus communis</i>	Higuereta	
	<i>Sapium laurocerasus</i>	Hinchahuevos	
	Fabaceae	<i>Aeschynomene americana</i>	Morivivi bobo
		<i>Centrosema pubescens</i>	Conchita
<i>Crotalaria retusa</i>		Matraca	
<i>Crotalaria striata</i>		Matraca	
<i>Dalbergia monetaria</i>		Bejuco de chavos	
<i>Desmodium canum</i>		Zarabacoa	
<i>Desmodium</i> sp.		Trébol	
<i>Erythrina corallandelianum</i>		Machete	
<i>Phaseolus vulgaris</i>		Habichuela	
<i>Gliricidia sepium</i>		Mata ratón	
<i>Mucuna sloanei</i>		Mato	
<i>Ormosia krugii</i>		Palo de matos	
<i>Pueraria hirsuta</i>		Kudzú	
<i>Tephrosia toxicaria</i>	Barbasco de raiz		
Gesneriaceae	<i>Gesneria albiflora</i>	Unknown	
Gramineae	<i>Andropogon nardus</i>	Limoncillo	
	<i>Cynodon dactylon</i>	Bermuda	
	<i>Eriochloa polystachya</i>	Malojilla	
	<i>Cynerium sagittifolia</i>	Caña india	
	<i>Panicum muticum</i>	Malojillo	
	<i>Panicum maximum</i>	Yerba de guinea, gramalote, yerba Borinquen	
Guttifereae	<i>Calophyllum calaba</i>	María	

TABLE 2.—Continued

Family name	Genus and species	Common name
Hippocrateaceae	<i>Hippocratea volubilis</i>	Bejuco prieto
Iridaceae	<i>Tigrida pavonia</i>	Bejuco violeta
Lamiaceae	<i>Ocimum basilicum</i>	Albahaca
	<i>Coleus blumei</i>	Cóleo
	<i>Ocimum officinalis</i>	Albahaca blanca
Lauraceae	<i>Persea americana</i>	Aguacate
Liliaceae	<i>Aloe barbadensis</i>	Sábila
	<i>Aloe ferox</i>	Závila de jardín
	<i>Yucca aloifolia</i>	Aguja de Adán
	<i>Sanseveria guineensis</i>	Lengua de vaca
Lythraceae	<i>Lagerstroemia indica</i>	Astromelia
Lobeliaceae	<i>Lobelia longiflora</i>	Tibey
Lycopodiaceae	<i>Lycopodium cernuum</i>	Azufre vegetal
Malvaceae	<i>Montezuma speciosissima</i>	Maga
	<i>Urena lobata</i>	Cadillo de perro
Melastomaceae	<i>Miconia prasina</i>	Camasey
Meliaceae	<i>Guarea trichiloides</i>	Guaraguao
Menispermaceae	<i>Cissampelos pareira</i>	Bejuco de mona
Menyanthaceae	<i>Nymphoides humboldtianum</i>	Trébol de agua
Mimosaceae	<i>Samanea saman</i>	Saman
Moraceae	<i>Ficus indica</i>	Higo chumbo
Musaceae	<i>Heliconia psittocorum</i>	Unknown
Myrtaceae	<i>Pimenta racemosa</i>	Malagueta
	<i>Eugenia jambos</i>	Pomarrosa
	<i>Psidium guajava</i>	Guayaba
Nyctaginaceae	<i>Bougainvillea glabra</i>	Trinitaria roja
	<i>Mirabilis jalapa</i>	Don Diego de noche
Onagraceae	<i>Ludwigia leptocarpa</i>	Evening primrose
Piperaceae	<i>Piper aduncum</i>	Higuillo hoja menuda
	<i>Piper marginatum</i>	Higuillo oloroso
	<i>Piper peltata</i>	Piquiña
Plantaginaceae	<i>Plantago major</i>	Llantén
Polygalaceae	<i>Polygala paniculata</i>	Orosne
Polygonaceae	<i>Antigonon leptopus</i>	Coralillo
	<i>Polygonum punctatum</i>	Yerba de hicotea
Polypodiaceae	<i>Dryopteris dentata</i>	Helecho
	<i>Nephrolepis biserrata</i>	Unknown
	<i>Polypodium polycarpum</i>	Unknown
Portulacaceae	<i>Portulaca oleracea</i>	Verdolaga
Rosaceae	<i>Rosa</i> sp.	Rosa
Rubiaceae	<i>Borreria ocymoides</i>	Juana la blanca
	<i>Borreria verticillata</i>	Botón blanco
	<i>Chiococca alba</i>	Bejuco de berac
	<i>Diodia sarmentosa</i>	Unknown
	<i>Gonzalagumia hirsuta</i>	Rabo de ratón
	<i>Hamelia erecta</i>	Bálsamo
	<i>Ixora coccinea</i>	Cruz de Malta
	<i>Psychotria brachiata</i>	Palo de cachimbo
	<i>Psychotria grandis</i>	Espuela de galán
	<i>Randia aculeata</i>	Tintillo

TABLE 2.—Continued

Family name	Genus and species	Common name
Rutaceae	<i>Citrus aurantifolia</i>	Limón
	<i>Ruta chalapensis</i>	Ruda
Sapindaceae	<i>Paullinia pinnata</i>	Bejuco de guajanilla
	<i>Cupania americana</i>	Guara blanca
Solanaceae	<i>Serjania polyphylla</i>	Bejuco de costillas
	<i>Datura suaveolens</i>	Campana de París
	<i>Datura</i> sp. (hybrid)	Campana rosada
	<i>Physalis angulata</i>	Saca-buche
	<i>Solanum ciliatum</i>	Berenjena cimarrona
	<i>Solanum melongena</i>	Berenjena
Terminaliaceae	<i>Solanum seaforthianum</i>	Falsa belladona
	<i>Terminalia catappa</i>	Almendra
Typhaceae	<i>Typha domingensis</i>	Enéa
Urticaceae	<i>Urera baccifera</i>	Ortiga brava
	<i>Urera</i> sp.	Unknown
Vitaceae	<i>Cissus sicyoides</i>	Bejuco de caro
Verbenaceae	<i>Citharexylum fruticosum</i>	Péndula
	<i>Lantana camara</i>	Cuencas de oro
	<i>Lippia dulcis</i>	Póleo, Orozús
	<i>Pettita domingensis</i>	Capa blanca
	<i>Stachytarpheta cayennense</i>	Verbena

In this study, fresh unweighed small quantities of live roots, leaves and fruits of each plant were cut and ground with water in an omnimixer. Such samples were diluted to fill a water glass (325 ml) and left refrigerated overnight. Snails were added to these simple plant infusions and were observed after 24 and 48 h. These data were compared with untreated controls (snails kept in the same water without plant tissue). Those plants which exhibited toxicity against the snails were selected for a definitive screening. In screening, the plant materials were oven dried (50° C) and ground (Thomas Mill Model 3) to a fine powder. Pre-exposure water solutions (1%) were prepared prior to the test day and kept refrigerated overnight. The 1% solution without debris was diluted to 100, 200, 500 and 1,000 p/m. Snails were exposed to plant materials 24 h and observed after a 24-h recovery period. The criteria of snail death were inactivity, shell discoloration and in case of doubt, foul odor upon crushing. The water used was tap water, declorinated and filtered through charcoal, sand and limestone.

RESULTS

Among 200 plant species (representing 79 families), 30 were found to have molluscicidal activity against *L. cubensis* and *L. columella*. One or more plant parts of 13 species killed all snails at 100 p/m or less; three other species were effective at 200 p/m. *Hedychium coronarium*, or night

jasmin (seeds), was the most molluscicidal, comparatively four times as active as any other of the plants tested. The chemical stability of its active agent also exceeded that of the other plants. Locally it is a favorite plant because of its evening scent. Two other species of the same family (alpinaceae) were not molluscicidal.

In only one species were all plant parts uniformly molluscicidal at 100 p/m: *Solanum nodiflorum* (Solanaceae). Leaves of other plants active at this level included those of *Cestrum diurnum*, *C. laurifolium*, *C. macrophyllum*, *Capsicum frutescens* (Solanaceae), *Polyscias guilfoylei* (Araliaceae), *Casuarina equisetifolia* (Casuarinaceae), and *Cajanus cajan*. Similarly, the fruits of *C. diurnum*, *C. laurifolium*, *Capsicum frutescens*, *S. mammosum* (Solanaceae) and *Duggena hirsuta* (Rubiaceae); the seed of *Indigofera suffruticosa* (Fabaceae); and the roots of *Asclepias curassavica* (Asclepidaceae), and *Cajanus cajan* (Leguminosae) were active at 100 p/m. Although the *Cestrum* species were about as toxic as *S. nodiflorum*, their active agents lost toxicity when stored as dry powder.

Leaves and fruits of the plants surveyed were more often molluscicidal against lymnaeids than other plant parts. Whereas all parts of *S. nodiflorum* were toxic, only leaves and fruits of other species of Solanaceae were active. Some species, such as *Codiaeum variegatum*, sometimes gave positive and at other times negative results within a series of collections from the same area.

The seed cover of *Bursera simaruba* inhibited the development of lymnaeid eggs with 1000 p/m, while hatching of the fully developed eggs was retarded with 100 p/m. However, the dried, powdered material lost toxicity under storage.

Analysis of plant families under consideration showed a trend of molluscicidal activity for species of Solanaceae, 8 of 14 being toxic at relatively low concentrations. In contrast, only three of 15 species of Fabaceae, two of 12 Rubiaceae, one of six Verbenaceae and two of 13 Euphorbiaceae were found active. No toxic species were found among 9 Compositae and 6 Graminaceae. Comparisons with other families are unwarranted because too few species were tested, e.g., Phytolaccaceae, for which two species were toxic at 200 p/m, (table 3). Thus far, all plants found to be molluscicidal are dicots.

DISCUSSION

Biological control of lymnaeids by means of toxic plants may warrant continued study, especially if they can be reared where snail populations occur (12). If so, the cost of mollusciciding would be minimized, including expenditures for synthetic chemicals and dispersion equipment; moreover, ecological disruptions might be reduced (6). The use of locally available molluscicidal plants has been encouraged through the research

of Lemma (10), Lemma et al. (11), Krochmal & Lequesne (8) and Bond (3). It has been proposed that molluscicidal plants might be used to enhance other biological control measures, and possibly afford synergistic interrelationships (14).

From this study, *Solanum nodiflorum* was recognized as a favorable selection for comprehensive, molluscicidal investigations, since all parts of the plants were toxic for at least two lymnaeids (12). If such a plant could thrive in swampy areas, fallen leaves, flowers and fruits, and roots as well, might make the habitat unfavorable for snails. Roots of *Asclepias*

TABLE 3.—Analysis of molluscicidal activity per family, including non-toxic groups for which four (4) or more species were tested

Family	Number molluscicidal	Species total	Activity
			P/m
Acanthaceae	0	4	—
Alpinaceae	1	3	25
Apocinaceae	1	2	1000
Araceae	0	3	—
Araliaceae	1	2	100
Asclepidaceae	1	2	100
Basidiomicetae	1	1	1000
Burseraceae	1	1	1000
Casuarinaceae	1	1	100
Cesalpinaceae	0	7	—
Compositae	0	9	—
Cyperaceae	0	4	—
Euphorbiaceae	2	13	—
Fabaceae	3	15	100 and 1000
Graminaceae	0	6	—
Mimosaceae	2	2	1000
Onagraceae	1	2	1000
Oxalidaceae	1	1	1000
Phytolacaceae	2	2	200
Rubiaceae	2	12	100 and 1000
Solanaceae	8	14	100 and 1000
Verbenaceae	1	6	1000

crussavica, as well as other parts, are molluscicidal and this plant does grow in swampy areas. The family Solanaceae includes a number of molluscicidal members for consideration.

Seeds of *Hedychium coronarium* were the most molluscicidal plant material tested, and this species is also active against miracidia and cercariae of *Schistosoma mansoni* (18).

Considerations might be given to toxicities of germinating seeds and seedlings. Furthermore, it might be appropriate to survey for absence or occurrence of molluscicidal plants in favorable natural habitats of lymnaeids and other trematode vectors, especially *B. glabrata*, and for

unusual mortalities, as was done by Lemma (10).

Although all but one of the plants found to be molluscicidal have been dicots, the number of families and species involved in this study are too few to generalize. Absence of snails in habitats with dense monocot vegetation has been noted repeatedly, even when snails occur in conjoined foci. However, it may be the density rather than the kinds of plants that preclude habitation.

We believe, that the desirable features of a molluscicidal plant include 1) plant adaptability to wet environment; 2) dispersibility of the plant parts (leaves or fruits) in the habitat; 3) release of toxic substances from roots into water or soil; 4) stability of the toxic agent in water; and 5) no toxicity for cattle or sheep, and other organisms in the same habitat.

RESUMEN

En un ensayo por eliminación selectiva realizado en el laboratorio, se estudiaron las propiedades molusquicidas de 200 plantas de Puerto Rico. El estudio reveló que de las 200, 30 atacan a *Lymnaea cubensis* y *L. columella*. Dieciséis de las 30 fueron muy tóxicas para las limnéideas, pues a concentraciones de 25 a 200 p.p.m. todos los caracoles murieron. De las varias partes de las plantas que se estudiaron—semillas, raíces, frutas y hojas—las últimas dos fueron las más tóxicas. Solamente en el caso de *Solanum nodiflorum*, todas fueron tóxicas. Se discute cómo estas plantas molusquicidas podrían usarse en el control de enfermedades portadas por caracoles, así como las cualidades que deben tener.

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