Terrestrial Plants Molluscicidal to Lymnaeid Hosts of Fascioliasis Hepatica in Puerto Rico[1]

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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 trematodiases, 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 sppressing 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 worthly of definitive field trials in trematode control (2). Studies are in progress using the native *Sepedon caerulia,* 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 (*Phytolocca 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	*Hedychium coronarium*[2]	Nardo, Jazmín del río	Seeds	25
Apocynaceae	*Allamanda cathartica*[2]	Canario	Leaves	1000
Asclepidaceae	*Asclepias curassavica*	Algodoncillo	Roots	100
Araliaceae	*Polyscias guilfoylei*[2]	Arelia	Leaves and Stem	100 and 200
Burseraceae	*Bursera simaruba*	Almácigo	Seeds	1000
Basidiomicetae	*Unidentified Basidiomycete*	Unknown	All Parts	1000
Casuarinaceae	*Casuarina equisetifolia*	Pino	Fruits and Leaves	100 and 1000
Dioscoreaceae	*Dioscorea rotundata*	Ñame blanco	Leaves	1000
Euphorbiaceae	*Codiaeum variegatum*	Crotón	Leaves	1000
	Jatropha gossypifolium	Tuatúa	Leaves	1000
Fabeceae	*Andira inermis*	Moca	Roots	1000
	Cajanus cajan	Gandul	Roots and Leaves	1000
	Indigofera suffruticosa	Añil	Seeds	100
Mimosaceae	*Inga vera*	Guava	Roots and bulbs	1000
	Samanea saman[2]	Samán	Leaves	1000
Onagraceae	*Ludwigia angustifolia*	Hicotea	Leaves	1000
Phytolaccaceae	*Phytolacca rivinoides*[3]	Tinta, Juan de Vargas	Mature Fruits	200
	Phytolacca isocandra	Bella Sombra	Mature Fruits	200
Rubiaceae	*Duggenia hirsuta*[2]	Mata de mariposa	Fruits	100
	Genipa americana[2]	Jagua	Fruits (immature)	1000
Solanaceae	*Capsicum frutescens*	Ají	Leaves and Fruits	100
	Cestrum diurnum	Dama del día	Leaves and Mature Fruits	1000
	Cestrum laurifolium	Galán del monte	Leaves and Mature Fruits	100
	Cestrum macrophyllum[4]	Galán del monte	Leaves	100
	Lycopersicon esculentum	Tomate	Leaves	1000
	Solanum nodiflorum	Yerba mora	All Parts	100
	Solanum torvum	Berenjena cimarrona	Leaves	1000
	Solanum mammosum	Berenjena de cucaracha	Mature Fruits (Pulp)	100
Verbenaceae	*Clerodendron fragans*[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	*Crossandra infundibuliformis*	Doña Juana
	Justicia verticillata	Unknown
	Rusellia equisetiformis	Lluvia de coral
	Stethoma pectoralis	Curía
Alpinaceae	*Alpinia purpurata*	Purple Ginger
	Alpinia speciosa	Shell flower
Alismaceae	*Sagittaria lancifolia*	Saeta de agua
Amaranthaceae	*Amaranthus paniculata*	Unknown
	Achyranthes aspera	Unknown
	Petiveria alliacea	Anamú
Amarilidaceae	*Agave angustifolia*	Agave
	Agave furcryoides	Henequén
Amilaceae	*Centella asiatica*	Yerba de chavos
Anacardiaceae	*Mangifera indica*	Mango
Annonaceae	*Annona glabra*	Corazón cimarrón
	Annona muricata	Guanábana
Apocinaceae	*Nerium oleander*	Alelí
Araceae	*Dieffenbachia seguine*	Rábano
	Philondendron dubius	Yautía type
	Syngonium podophylum	Unknown
Araliaceae	*Aralia balfouriana*	Arelia
Asclepidaceae	*Cryptostegia grandiflora*	Bejuco de goma
Balsaminaceae	*Impatiens balsamina*	Espuela de galán
	Impatiens sultani	Miramelinda
Begoniaceae	*Begonia* sp.	Begonia
Bignoniaceae	*Crescentia cujete*	Higüero
Bixiaceae	*Bixia orellana*	Achiote
Boraginaceae	*Heliotropium indicum*	Cotorrera
Boraginaceae	*Tournefortia hirsutissima*	Nigua
Bromeliaceae	*Bromelia pyramidalis*	Bromelia
	Bromelia sp.	Bromelia
Cactaceae	*Hylocereus trigonus*	Pitahaya
	Cactus sp.	Ornamental cactus
Cambretaceae	*Bucida buceras*	Ucar
Cannaceae	*Canna* sp.	Maraca
Cesalpinaceae	*Biancaea sepiaria*	Zarza
	Cassia occidentalis	Hedionda
	Cassia mimosioides	Morivivi falso
	Cassia siamea	Casia
	Cassia tora	Hedionda
	Tamarindus indicus	Tamarindo
Characeae	*Chara* sp.	Chara
Commelinaceae	*Commelina virginiana*	Cohítre
	Rhoeo discolor	Sangría
Compositae	*Bidens pilosa*	Margarita silvestre
	Calendula erecta	Caléndula
	Mikania cordifolia	Guaco
	Mikania fragilis	Unknown
	Parthenium hysterophorum	Ajenjo cimarrón
	Pluchea odorata	Salvia
	Pseudoelephantopus spicatus	Lengua de vaca
	Wedelia trilobata	Manzanilla de playa

TABLE 2.—*Continued*

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

TABLE 2.—*Continued*

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

TABLE 2.—*Continued*

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