RESEARCH ARTICLE

Mga tanom na nakakabulong: Medicinal plant studies among the undergraduate researches of Bicol University – Department of Biology from 1991 to 2019

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ABSTRACT

Background: Undergraduate researches in universities are potential sources of useful data in medicinal plant research. In higher education institutions, many of these manuscripts remain untapped and inaccessible to researchers and scientists. If widely utilized, these can contribute in the growth of knowledge on medicinal plants.

Objectives: This article aimed to catalogue the medicinal plant researches of the Bicol University – Department of Biology from 1991 to 2019, highlight significant developments, trends, and responsiveness of the research, and recommend policies to improve medicinal plant research in the next decade.

Methodology: A complete list of undergraduate research titles was obtained and analyzed using the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) process. Categorization of researches included the medicinal plants studied, year of study, and the biological assays conducted. The final list included two things: researches that utilized medicinal plants and those researches which tested the biological and medicinal properties of plants. Results were presented in percentages.

Results: To date, 18.72% of the 865 thesis titles archived in the department are medicinal plant researches and majority of which focused on antimicrobial and toxicity studies. There were 52 plant families, 99 genera, and 114 plant species investigated. Leguminosae and Asteraceae were the most studied plant families. The years 2011-2019 were the most fruitful in terms of research completed.

Conclusion: Undergraduate researches can provide vital information on medicinal plants studies, especially on an institutional and regional level. It is recommended that medicinal plants research be included as a thematic area among higher education institutions, and that policies be implemented to support publication of researches.

Keywords: *Burseraceae, Asteraceae, Canarium ovatum, higher education, IACUC, biological assay, anti-infective agents, anti-bacterial agents*

Introduction

In the Philippines, medicinal plants are part of the way of life, especially in the rural areas. A newly circumcised male in the province may be advised to boil *Psidium guajava* L. (guava) leaves to apply to the wound as an antiseptic [1] and to expedite the healing process. Children may be given some combinations of *Blumea balsamifera* (L.) DC (sambong) and other leaves to place on their foreheads to relieve fever [2]. Others use the scent of citrus to ward off nausea and vomiting. The use of plants or plant parts and their preparation may vary from region to region, and even among families in the area. This is suggestive of the cultural influence and acceptance of plant-based drugs from local sources [3].

Although only 10 are officially recommended by the Department of Health [4], rural and indigenous communities still continue to utilize other plants to treat a variety of ailments. These practices have been widely documented in many ethnobotanical surveys. For example, the Kalanguya tribe of the northern province of Ifugao has uses for 125 plant species to treat ailments [5]. The Ati Negrito indigenous groups in the island province of Guimaras in Central Philippines also use at least 142 medicinal plants in 16

categories of diseases [6]. Many more ethnobotanical surveys have been conducted among the Higaonon tribe in Iligan City, Mindanao [7], the Aeta communities of Bataan [8], the Manobo tribe in Agusan [9], and the Talaandig tribe of Bukidnon [10]. Medicinal plants remain a source of cure for both mild and severe ailments, and in the conduct of traditional therapies [11] in the country, especially in indigenous communities [12]. Traditional healers or *herbolarios* are also instrumental in the wide use of medicinal plants in rural communities [13,14].

Research on the medicinal properties of plants have tremendously grown through the years. Researchable areas include the bioactivities of the plant, their safety (*e.g.* safe doses) to users, and the standardization of methods for their extraction and commercialization [15]. Indigenous plants In the Philippines have been tested for their antibacterial activities [16], antioxidant and cytotoxic activities [17], angio-suppresive activity [18] and cancer chemotherapeutic potential [19], among others.

While there is extensive knowledge being generated in research institutions, universities are also generating extensive reservoir of knowledge in the form of undergraduate researches [20]. These include thesis manuscripts and undergraduate special problems, and these have potential to contribute to existing knowledge [21]. However, many of these academic outputs remain untapped due to inaccessibility to researchers and scientists.

Among the 865 undergraduate researches of the Biology Department of Bicol University, 162 of which are investigations of medicinal or biological properties of plants. All undergraduate researches remained archived and inaccessible to the general public, or to local and international researchers ever since the first medicinal plant research was completed in the department in 1991. These undergraduate studies underwent formal review in the form of a thesis defense. Although there are some key considerations, such as the limit of the review process at the undergraduate level, the resulting researches may be candidate sources of useful data. This scenario may be reflective of other higher education institutions in the country. A cursory investigation of the thesis can provide historical data on trends and focus in terms of medicinal plants research.

Notwithstanding the content and the result of these researches, performing a bibliometric analysis using titles and abstracts is important for two reasons. First, it is a step in improving local knowledge management of the university. Second, and more important, is that it expedites the careful assimilation of traditional knowledge generated from local researches into a database accessible to other institutions [22].

Thus, this research is an analysis of the medicinal plant studies conducted by the Department of Biology of Bicol University in the Philippines. Using titles and abstracts in the official list of completed researches, this aimed to catalogue the plants investigated from 1991 to 2019 (28 years), highlight trends and focus, give insights into the missed opportunities, and provide recommendations for the improvement of medicinal plant research in the university. Undergraduate researches are important contributions that can influence policies and existing protocols [23], especially when communicated properly to decision makers [24].

Methodology

Biology Department of Bicol University

The Biology Department was previously known as the Department of Natural Sciences in 1983 and was one of the several departments of the defunct College of Arts and Sciences of Bicol University. Following the Comprehensive Development Plan of the university in 2004, the department is now part of the College of Science. Students enrolled in the program are required to submit a thesis at the end of their fourth year as a final requirement prior to being granted a bachelor's degree in Biology. Thesis manuscripts are bound and submitted in triplicate to provide copies for the following: the university library, the college research office, and the biology department.

Selection of undergraduate researches

The Biology Department of Bicol University maintains an official list of thesis titles from 1985 to 2019 comprising 865 thesis titles. Access to this file is open to faculty members of the department. A bibliometric and systematic review was done using both the thesis titles and the corresponding abstracts. Using Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) process [25], titles were filtered to include keywords such as “medicinal plants”, “medicinal property”, “biological activities”, and several keywords referring to any of these broad leads. The final list included two things: first, those researches that utilized medicinal plants, and second, those researches

which tested the biological and medicinal properties of plants. Abstracts were checked so that those which merely tested biological properties were linked by the authors to medicinal activities or properties. Hardbound copies available at the department library and the university central library were consulted when the softcopy files were not available. The entire thesis manuscripts were not used in this research because they remain as copyrighted materials of the students. Likewise, the authors opted not to use the manuscript so that student researchers are not pre-empted when they finally decide to publish their works.

Researches were grouped according to the following basic information: date of completion, medicinal plants used, and plant activities tested. Plant families and plant parts used in the assays were also reported. The collected data were then presented in percentages.

Results

Medicinal plant research represented 18.72% of the 865 undergraduate researches in the Department of Biology. There were 114 plants investigated in the past 28 years of undergraduate research in 162 research titles. Toxicity and antimicrobial studies dominated the medicinal plant research with 19.77% and 14.53% of the total number of medicinal plant research, respectively.

Medicinal plant research by year

The first undergraduate research conducted using a medicinal plant was in 1991 on the antibacterial activity of *Plumeria acuminata* Ait. (kalachuchi) leaves, bark, and roots against *Staphylococcus aureus* Rosenbach. From 1992 through 1997, no medicinal plant research was conducted

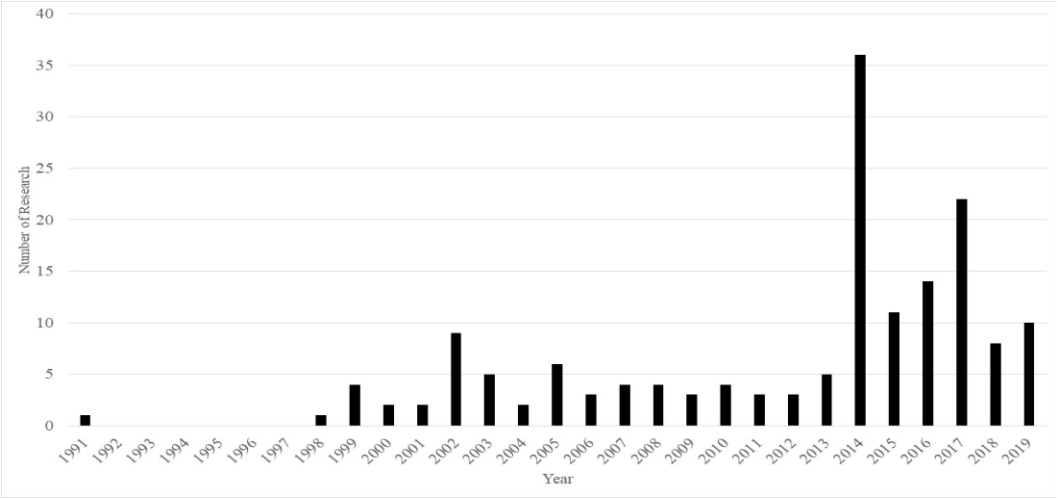

Figure 1. *Number of medicinal plant researches per year*

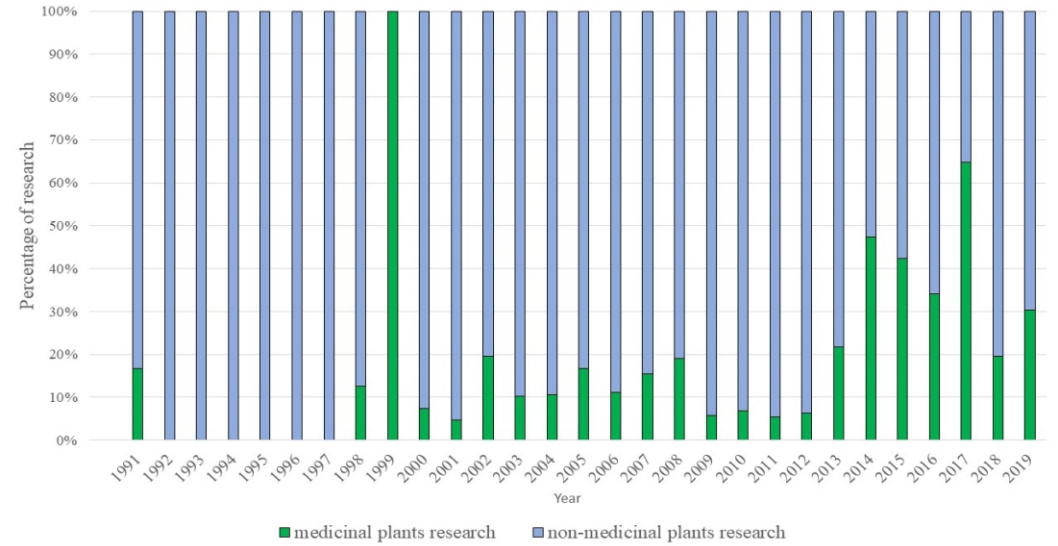

Figure 2. *Percentage of medicinal plant researches vs non-medicinal plant researches per year*

(Figures 1 and 2). In these six years, researches in the department focused towards agriculture, fisheries, or biodiversity studies. During these six years, the plants used were assayed for their activities against plant pathogens or insect pests and in improving quality of *Gallus gallus domesticus* L. (chicken) or economically important bivalves such as *Paphia amabilis* Philippi (green mussel). In 1998, *Datura metel* L. (kalampunay) was screened for its toxicity in albino R*attus novergicus* Berkenhout (rat), along with its hallucinogenic activity. The first decade (1991-2000) of medicinal plant research had only produced 8 researches.

During the second decade (2001-2010), medicinal plant research gained traction, mostly on microbiology and general toxicity assays. In the latest decade (2011-2019), a surge of interest was noted. The highest number of medicinal plant research was in 2014 with a total of 36 studies. This was 47.37% of the total number of researches compared with the 16.67% biodiversity researches produced in that same year. In 2015, students were allowed to conduct research by pair, and in 2016 by threes. While the department had more students enrolled in the program, there is reduction in the number of researches in the department by approximately half. For example, there were only a total of 34 researches in 2017 even though there were 100 students enrolled in the program. Proportionally, 64.71% were medicinal plant research that year.

Medicinal plant research in terms of plant family

Fifty-two plant families were already investigated (Table 1). Leguminosae Juss. had the greatest number of species studied with 10 species (*Arachis hypogaea* L., *Biancaea sappan* (L.) Tod., *Caesalpinia pulcherrima* (L.) Sw., *Derris elliptica* (Wall.) Benth, *Gliricidia sepium* (Jacq.) Steud., *Glycine max* (L.) Merr., *Indigofera suffruticosa* Mill., *Mimosa pudica* L., *Pachyrhizus erosus* (L.) Urb., and *Tamarindus indica* L.) together with *Asteraceae* Bercht. & J.Presl with another 7 species (*Acmella oleracea* (L.) R.K. Jansen, *Artemisia vulgaris* L., *Blumea balsamifera*, *Chrysanthemum indicum* L., *Cyanthillium cinereum* (L.) H.Rob, *Elephantopus tomentosus* L., and *Sphagneticola trilobata* (L.) Pruski). Five species belonging to Myrtaceae were studied, all of which are in genus *Syzygium*: *S. albayense* Merr., *S. cumini* (L.)

Table 1. *Plant species researched from 1991 to 2019.*

Family	Number of Species studied	Genus	Species	English common name	Filipino name	Common use* or habit	Number of researches
Acanthaceae	1	*Thunbergia*	*Thunbergia grandifolia*	bengal vine	blue sunflower	Ornamental	1
Achariaceae	1	*Hydnocarpus*	*Hydnocarpus alcalae*	dudoa	dudoa	Tree	1
Alliaceae	1	*Allium*	*Allium sativum*	garlic	bawang	Food	1
Amaranthaceae	1	*Amaranthus*	*Amaranthus spinosus*	pigweed	uray	Weed	1
Amaryllidaceae	1	*Proiphys*	*Proiphys amboinensis*	cardwell lily	tambal	Ornamental	1
Annonaceae	2	*Annona*	*Annona muricata* *Annona squamosa*	soursop sugar apple	guyabano atis	Food Food	3 2
Apiaceae	1	*Daucus*	*Daucus carota*	carrot	karot	Food	1
Apocynaceae	5	*Allamanda* *Alstonia* *Catharanthus* *Hoya* *Plumeria*	*Allamanda cathartica* *Alstonia scholaris* *Catharanthus roseus* *Hoya carnosa* *Plumeria acuminata*	golden trumpet blackboard tree periwinkle porcelain flower kalachuchi	kampanilya dita tsitsirika hoya kalachuchi	Ornamental Tree Ornamental Ornamental Ornamental	1 2 2 1 1
Araceae	1	*Colocasia*	*Colocasia esculenta*	gabi or taro	gabi	Food	3
Arecaceae	2	*Areca* *Cocos*	*Areca catechu* *Cocos nucifera*	betel nut coconut	bunga niyog	Tree Food	2 4
Asteraceae	7	*Acmella* *Artemisia* *Blumea* *Chrysanthemum* *Cyanthillium* *Elephantopus* *Sphagneticola*	*Acmella oleracea* *Artemisia vulgaris* *Blumea balsamifera* *Chrysanthemum indicum* *Cyanthillium cinereum* *Elephantopus tomentosus* *Sphagneticola trilobata*	paracress mugwort Ngai camphor chrysanthemum little ironweed elephant's foot trailing daisy	biri artemisa sambong manzanilla kolong-kugon dila-dila wedelia	Food Medicinal Medicinal Ornamental Weed Weed Ornamental	1 3 1 1 1 1 2
Boraginaceae	1	*Cordia*	*Cordia dichotoma*	soap berry	anonang	Medicinal	1

Family	Number of Species studied	Genus	Species	English common name	Filipino name	Common use* or habit	Number of researches
Brassicaceae	2	*Raphanus*	*Raphanus sativus*	radish	labanos	Food	1
		Brassica	*Brassica oleracea*	cabbage	repolyo	Food	2
Bromeliaceae	1	*Ananas*	*Ananas comosus*	pineapple	pinya	Food	3
Burseraceae	1	*Canarium*	*Canarium ovatum*	pili	pili	Food	15
Cannabaceae	1	*Trema*	*Trema orientalis*	charcoal tree	anabiong	Tree	2
Caricaceae	1	*Carica*	*Carica papaya*	papaya	tapayas	Food	3
Cleomaceae	1	*Cleome*	*Cleome rutidosperma*	fringed spider flower	seru-walai	Weed	1
Combretaceae	2	*Combretum*	*Combretum indicum*	Chinese honeysuckle	niyog-niyogan	Ornamental	1
		Terminalia	*Terminalia catappa*	talisay	talisay	Tree	2
Convolvulaceae	2	*Ipomoea*	*Ipomoea batatas*	potato	patatas	Food	3
		Merremia	*Merremia peltata*	morning glory	bulakan	Vine	2
Cucurbitaceae	1	*Momordica*	*Momordica charantia*	bitter gourd	ampalaya	Food	2
Dioscoreaceae	1	*Dioscorea*	*Dioscorea hispida*	three-leaved yam	nami	Food	1
Euphorbiaceae	4	*Euphorbia*	*Euphorbia milli*	crown of thorns	corona de espina	Ornamental	1
		Jatropha	*Jatropha curcas*	purging nut	tubang bakod	Industrial (fuel)	4
		Manihot	*Manihot esculenta*	cassava	kamoteng kahoy	Food	2
		Ricinus	*Ricinus cummunis*	castor bean	tangan-tangan	Ornamental	1
Lamiaceae	5	*Gmelina*	*Gmelina arborea*	gmelina	gmelina	Tree	3
		Ocimum	*Ocimum basilicum*	great basil	balanoy	Food	2
			Ocimum tenuiflorum	holy basil	sulasi	Medicinal	1
		Orthosiphon	*Orthosiphon aristatus*	cat's whiskers	balbas pusa	Medicinal	2
		Plectranthus	*Plectranthus amboinicus*	Mexican mint	oregano	Medicinal	1
Lauraceae	2	*Laurus*	*Laurus nobilis*	bay tree	laurel	Tree	1
		Persea	*Persea americana*	avocado	abokado	Food	2
Leguminosae	10	*Arachis*	*Arachis hypogaea*	peanut	mani	Food	5
		Biancaea	*Biancaea sappan*	sappanwood	sibukao	Tree	1
		Caesalpinia	*Caesalpinia pulcherrima*	peacock flower	bulaklak ng paraiso	Ornamental	1
		Derris	*Derris elliptica*	tuba root	tubli	Fish poison	1
		Gliricidia	*Gliricidia sepium*	madre de cacao	kakawate	Tree	2
		Glycine	*Glycine max*	soybean	soya	Food	1
		Indigofera	*Indigofera suffruticosa*	wild indigo	tayum	Ornamental	1
		Mimosa	*Mimosa pudica*	sleepy plant	makahiya	Weed	2
		Pachyrhizus	*Pachyrhizus erosus*	Mexican turnip	singkamas	Food	2
		Tamarindus	*Tamarindus indica*	tamarind	sampalok	Food	2
Lythraceae	2	*Lagerstroemia*	*Lagerstroemia speciosa*	banaba plant	banaba	Medicinal	1
		Punica	*Punica granatum*	pomegranate	granada	Food	1
Malvaceae	1	*Theobroma*	*Theobroma cacao*	cacao	kakaw	Food	3
Meliaceae	4	*Azadirachta*	*Azadirachta indica*	neem tree	marrango	Tree	1
		Chisocheton	*Chisocheton cumingianus*	balukanag	ubot	Tree	1
		Sandoricum	*Sandoricum koetjape*	wild mangosteen	santol	Food	1
		Swietenia	*Swietenia mahogani*	mahogany	mahogany	Tree	1
Menispermaceae	1	*Tinospora*	*Tinospora crispa*	heavenly elixir	makabuhay	Medicinal	2
Moraceae	5	*Artocarpus*	*Artocarpus altilis*	breadfruit	kamansi	Food	1
		Ficus	*Ficus benjamina*	weeping fig	balete	Tree	1
			Ficus elastica	rubber fig	balete	Tree	1
			Ficus pseudopalma	Philippine fig	niyog-niyogan	Food	5
			Ficus septica	Hauli tree	hauili	Tree	1
Moringaceae	1	*Moringa*	*Moringa oleifera*	horseradish	malunggay	Food	1
Musaceae	2	*Musa*	*Musa sp.*	banana	saging	Food	5
			Musa textilis	Manila hemp	abaka	Industrial	1

Family	Number of Species studied	Genus	Species	English common name	Filipino name	Common use* or habit	Number of researches
Myrtaceae	5	*Syzygium*	*Syzygium albayense*	common plum	duhat	Food	1
			Syzygium cumini	black plum	duhat	Food	2
			Syzygium curanii	lipote	lipote	Food	2
			Syzygium polycephaloides	baligang	baligang	Food	2
			Syzygium tripinnatum	hagis	hagis	Food	1
Nephrolepidaceae	1	*Nephrolepsis*	*Nephrolepsis cordifloria*	fishbone fern	bayabang	Ornamental	1
Oxalidaceae	1	*Averrhoa*	*Averrhoa carambola*	star fruit	balimbing	Food	1
Pandanaceae	1	*Pandanus*	*Pandanus odorifer*	screw pine	pandan	Food	1
Phyllanthaceae	3	*Antidesma*	*Antidesma bunius*	currant tree	bignay	Food	1
		Breynia	*Breynia vitis-idaea*	formosa breynia	matang hipon	Weed	1
		Phyllanthus	*Phyllanthus niruri*	stonebreaker	sampa-sampalukan	Weed	2
Piperaceae	1	*Piper*	*Piper betle*	betel	ikmo	Food	3
Pittosporaceae	1	*Pittosporum*	*Pittosporum resiniferum*	petroleum nut	abkel	Epiphyte	1
Plantaginaceae	1	*Bacopa*	*Bacopa monnieri*	water hyssop	ulasimang aso	Ornamental	1
Poaceae	3	*Cymbopogon*	*Cymbopogon citratus*	lemon grass	tanglad	Food	2
		Paspalum	*Paspalum conjugatum*	carabao grass	laua laua	Ornamental	1
		Pennisetum	*Pennisetum purpureum*	napier grass	buntot pusa	Feed	1
Polypodiaceae	2	*Drynaria*	*Drynaria quercifolia*	oakleaf fern	pakpak lawin	Ornamental	1
		Pyrrosia	*Pyrrosia piloselloides*	dragon's scale fern	pagong-pagongan	Ornamental	1
Rosaceae	1	*Malus*	*Malus domestica*	apple	mansanas	Food	1
Rubiaceae	2	*Coffea*	*Coffea arabica*	coffee	kape	Food	1
		Morinda	*Morinda citrifolia*	noni	apatot	Tree	1
Rutaceae	3	*Citrus*	*Citrus x aurantifolia*	key lime/dayap	dayap	Food	1
			Citrus maxima	pomelo	suha	Food	2
		Triphasia	*Triphasia trifolia*	lime berry	limonsito	Ornamental	1
Salicaceae	1	*Flacourtia*	*Flacourtia indica*	governor's plum	palutan	Tree	1
Sapotaceae	1	*Manilkara*	*Manilkara zapota*	sapodilla	chiko	Food	1
Solanaceae	5	*Datura*	*Datura metel*	devil's trumpet	talong punay	Ornamental	1
		Solanum	*Solanum lycopersicum*	tomato	kamatis	Food	2
			Solanum melogena	eggplant	talong	Food	1
			Solanum nigrum	nightshade	bolagtab	Weed	1
			Solanum torvum	prickly nightshade	tandang aso	Weed	1
Verbenaceae	2	*Lantana*	*Lantana camara*	common lantana	kantutay	Weed	1
		Stachytarpheta	*Stachytarpheta jamaicensis*	blue snakeweed	kandikandilaan	Weed	3
Woodsiaceae	1	*Diplazium*	*Diplazium esculentum*	vegetable fern	pako	Food	3
Zingiberaceae	5	*Alpinia*	*Alpinia galanga*	greater galangal	langkwas	Food	2
			Alpinia purpurata	red ginger	luyang pula	Ornamental	1
		Curcuma	*Curcuma longa*	turmeric	luyang dilaw	Food	2
		Kaempferia	*Kaempferia galanga*	aromatic ginger	dusol	Food	4
		Zingiber	*Zingiber officinale*	ginger	luya	Food	4

*may vary from place to place

Skeels., *S. curranii* C.B. Robinson, *S. polycephaloides* (C.B. Robinson) Merr., and *S. tripinnatum* (Blanco) Merr. In terms of number of researches, Leguminosae was the most studied plant family with eighteen researches, followed by Burseraceae Kunth with fifteen researches. Burseraceae is solely represented by *Canarium ovatum* Engl. (pili), an economically important indigenous plant in the Bicol region because of its nut, kernel, and derivatives.

Most undergraduate researches were focused on a single plant. Comparative studies were first done in 2002 by comparing the antibacterial activities of *Terminalia catappa* L., *S. cumini* and *I. suffruticosa* against *S. aureus*. A total of 14 studies from 2002 to 2019 involved multiple plants in comparative studies.

It can also be observed that majority of the plants investigated were commonly used as food. Fifty-one (51) of

the plants used in research are eaten as fruit or vegetable servings. Twenty-one (21) of the plants are cultivated as ornamentals, and 13 are considered as weeds or invasive vine or epiphytes. This classification, however, may differ geographically because of the differences in how plants are utilized. Only 8 plants are cultivated primarily for medicinal purposes: *A. vulgaris*, *B. balsamifera*, *Cordia dichotoma* G. Forst., *Plectranthus amboinicus* (Lour.) Spreng, *Ocimum tenuiflorum* L., *Orthosiphon aristatus* (blume) Miq., *Lagerstroemia speciosa* (L.) Pers., and *Tinospora crispa* (L.) Hook. F. & Thomson. Seventeen (17) of the plants are trees and among them, only *Hydnocarpus alcalae* C.DC. is endemic to the province of Albay. Among the ten medicinal plants recommended by the Philippine Department of Health, only six were investigated by the department: *Momordica charantia* L., *Allium sativum* L., *P. guajava*, *Vitex negundo* L., *Combretum indicum* (L.) DeFlipps, and *B. balsamifera.*

Medicinal plant research in terms of plant parts used

Fifty-seven percent (57%) of the studies used the leaves as the source of medicinal activities. Leaves were either used alone or in comparison with other plant parts (Figure 3). Fruits were used 18% of the time; this included all fruit parts (*e.g.* pulp and endosperm). *Canarium ovatum,* with at least 15 studies, is the single most studied plant in the department. Its leaves and fruit pulp were studied five times each and the remainder made use of the root, bark and the kernel oil.

Medicinal plant research in terms of activities

Toxicity and antimicrobial assays were among the most common research themes (Table 2). Toxicity assays include chronic, acute and sub-acute assays in the early years of the department utilizing mostly albino *Mus musculus* L. (mice) of the ICR strain. Eventually, this diversified into mutagenicity, cytotoxicity, and teratogenicity assays. Test organisms (Figure 4) include animal models such as the *Danio rerio* (F. Hamilton) (zebra fish), *Anas platyrhynchos* L. (duck) embryo, and *Tripneustes gratilla* L. (sea urchin). *Rattus* sp. (rat) was also used alternatively with the mice models.

From 1991 to 2004, as antimicrobial assays were very specific in their scope, plants were tested only either against *S. aureus* or *Escherichia coli* (Migula) but not to both. The first record of using microorganisms to represent both Gram-positive and Gram-negative groups was in 2005, testing the antibacterial activity of *M. pudica* (makahiya) leaf and root. Antifungal assays, on the other hand, were first conducted against *Trichophyton rubrum* (Castell.) Sabour. using extracts of *Cocos nucifera* L. (coconut) endosperm and mesoderm. In addition, antifungal assays used *Candida albicans* (C.P. Robin) Berkhout and *Aspergillus flavus* Link as test organisms. More antibacterial assays (15 researches) were conducted than antifungal assays (6), and 4 studies investigated both activities together. Two studies used human blood to test coagulant and anticoagulant

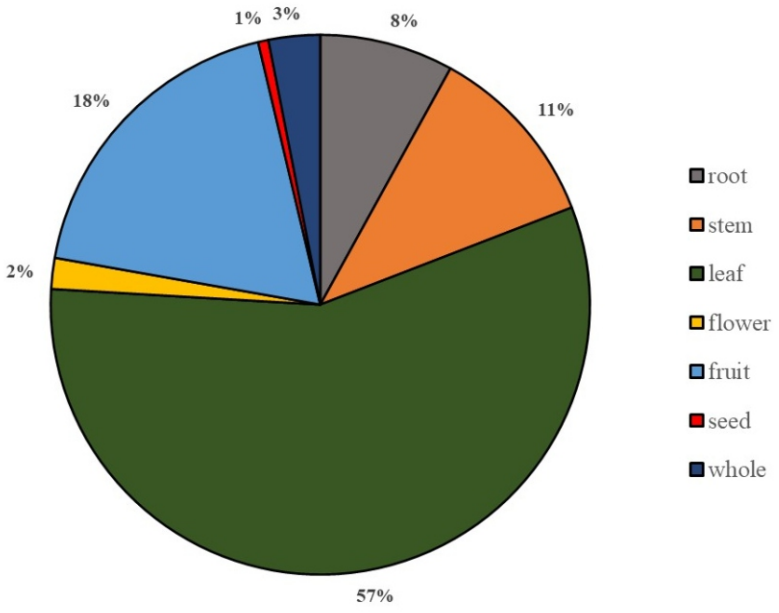

Figure 3. *Percentage of medicinal plant researches in terms of plant parts used*

Table 2. *Medicinal plant research in terms of activities investigated.*

Activity	Description	Number of Researches[1]	Percentage
toxicity assay	chronic, acute, and sub-acute toxicity, genotoxicity, mutagenicity, cytotoxicity, teratogenicity	34	19.77
antimicrobial	antibacterial, antifungal	25	14.53
histo-physiological	anti-hemorrhoidal, urolithialic, anti-convulsant, anti-spasmodic, anti-inflammatory, anti-pyretic, anti-asthmatic, anti-nociceptive, anti-diabetic	23	13.37
biochemical	glycemic, lipidemic, peruricemic, antioxidant	16	9.30
neurological	hallucinogenic, behavioral, learning, anxiolytic, anxiogenic, brain development	14	8.14
hematological	coagulant, anticoagulant, erythropoietic, thrombocytopenic	13	7.56
protective	hepatoprotective, nephroprotective, neuroprotective, pancreatoprotective, hemoprotective	12	6.98
reproductive	male and female fertility, contraceptive, histochemistry	11	6.40
wound healing	burns, cuts, incised wounds	8	4.65
antihelminthic	anti-helminthic	8	4.65
cardio-vascular	anti-hypertensive, angiogenic	6	3.49
immunological	anti-immunosuppresive, immunomodulatory	2	1.16
	TOTAL	172	100

[1]Some researches made use of two or three medicinal plants

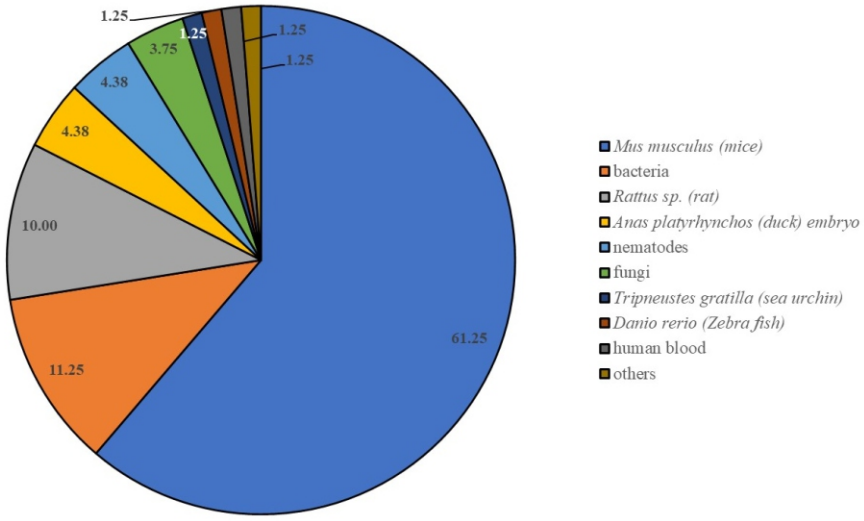

Figure 4. *Percentage of medicinal plant researches in terms of test organisms used*

properties of *Musa* (L.) sp. (banana) and *Moringa oleifera* Lam. (malunggay) leaves, respectively.

Development and responsiveness of medicinal plant research

Significant development was evident in the types of research conducted along medicinal plant studies. Biochemical components were incorporated into the objectives of the studies, in addition to simply knowing the effects of plants. Medicinal plants were screened for phytochemical families such as flavonoids, alkaloids, and phenols. This was a major consideration partly due to the improvement in the extraction procedures employed. Prior to 2004, extraction procedures yielded aqueous extracts. Solvents, primarily ethanol and methanol, were used starting 2005 and this funneled down phytochemicals that may explain subsequent bioactivities.

New biological activities were also investigated starting 2014. Activities such as antipyretic, hepatoprotective, and anti-inflammatory were first conducted the same year.

Likewise, with the return of faculty members on study leave and the addition of faculty members with new expertise, new research topics were explored along developmental studies, biofilm, and *in vitro* assays.

Discussion

Challenges and opportunities for medicinal plant research

The challenge and opportunity for a substantial medicinal plants research cannot be determined by the number of research outputs per year. The research has to be agenda-driven and cohesive in nature. There are many limitations to the conduct of undergraduate research in the sciences. Among them include the lack of a pool of experts and professionals as well as the lack of infrastructure support and equipment to conduct succinct and comprehensive assays [26]. This is where institutions must be creative in their strategies to produce high quality researches with minimal resources. For instance, it can be assumed that all plants have a medicinal property [27] and that the broadest definition of medicinal plant includes those with known or alleged medicinal properties [28]. To avoid randomness in choosing medicinal plants to study, institutions may create a medicinal plants research agenda wherein a particular family can be prioritized. Plants indigenous to the region and those with folkloric uses may also be given premium. This is why this study is important because it provides a list of plants already investigated, the plant parts analyzed, and the assays conducted. An internal or institutional database of medicinal plants is warranted so that resources are managed properly.

Moving beyond the institution, the richness of the Philippine flora and the Philippine indigenous knowledge are two sources of opportunities for medicinal plant research. The checklist for orders and families of medicinal plants in the Philippines continue to grow [29] and undergraduate studies can contribute to enrich this body of knowledge. Mount Malinao in the province of Albay has 27 endemic plants [30] while Mount Mayon Natural Park in the same province is habitat to 23 Philippine endemic trees [31]. While the department is keen on studying medicinal plants, a comprehensive documentation of their uses in barangays in the region may provide depth as to why such exploration is necessary. Ethnobotanical surveys and pharmacognosy are vital in this aspect which can be strengthened by local universities because they are closest to the communities. Communities with no access to formal healthcare greatly rely on medicinal plants to address their health needs. Among communities in Cebu [32], Batan Island [12], and Zamboanga [33], medicinal flora was surveyed and have yielded important insights into how communities utilize plants for their health benefits.

In relation to this, conservation of medicinal plants is also important, not only because these provide health benefits, but its exploitation may threaten its indigenous status and consequently their genetic diversity [34,35]. With the growing literature on its health benefits, problems arise as exploitation and premature harvesting may lead to unrecoverable loss of germplasm [36]. Threatened medicinal plants due to market demands are well-documented [37] especially across the Himalayas region [38,39]. Although no documentation was done in the Philippines on threatened medicinal plants, the shaving of forests and conversion of lands to become residential and industrial lands is an umbrella threat to biodiversity, including medicinal plants. A few researches in the Philippines have undergone initiatives to document conservation status of medicinal plants such as those in Mount Arayat National Park in Pampanga [40].

Likewise, some taxonomic names of plants need updating primarily because the researches were conducted in the 1990s. Among the plants included in this research, 6 plants already have updated taxonomic names: *Eurycles amboinensis* is already known as *Proiphys amboinensis* (L.) Herb, *Coleus aromaticus* as *Plectranthus amboinicus*, *Citrus grandis* as *Citrus maxima* Merr., *Tachytarpheta jamaicensis* as *Stachytarpheta jamaicensis* (L.) Vahl., *Ocimum sanctum* as *Ocimum tenuiflorum* L., and *Quisqualis indica* as *Combretum indicum*. This underlines the importance of systematics and taxonomy in medicinal plants research. Without a proper binomial, the results cannot be correlated to those existing in literature [41]. This points to the need to submit plant materials for authentication and deposit such as voucher specimen in a reputable museum.

In vitro methodologies may also be looked into as alternative to live biological models especially when a standard animal facility is not in place. In the case of Bicol University, no institutional animal care and use committee (IACUC) was in place prior to 2016. Thus, it was not a common practice for researches with animal models to seek IACUC clearance prior to the conduct of the study. Although this has been established in the last 3 years, this committee remains inactive and non-accredited by the Bureau of Animal Industry. Furthermore, in studies where mice and rats were used in the biology department, animals had to be ordered and transported from the University of the Philippines Diliman, Research Institute for Tropical

Medicine, and Bureau of Animal Industry in the capital city of Manila either by a ten-hour bus ride or a one-hour plane trip. Absence of a functional IACUC is a major setback for paper presentations and publication, and also because practices and procedures are devoid of a standard oversight.

While *in vitro* experiment does not truly replicate a biological system [42], it eliminates impediments such as physiology and biochemistry active in live biological models. Also, this reduces the use of animal models for testing, a move now highly welcomed by animal welfare advocates. It requires less space, facilities, and maintenance.

The rate at which a particular plant of interest is being studied simultaneously across the world is a challenge and an opportunity. With the drive to validate folkloric uses and to create better drug alternatives, it would not be surprising to find plants already studied in the literature prior or almost at the same time as the student undergraduate thesis. This underlines the need to publish the results, especially when it is promising, to contribute redirecting medicinal plant research. To cite an example, the first medicinal plants research of the biology department on the antibacterial property of *P. acuminata*, conducted in 1991, already exists in literature as published articles in 2008 [43]. The research of the department could have been published and contributed as a literature to the conduct of the succeeding researches. Based on traceable online record, only two undergraduate researches in the biology department of Bicol University were published in a journal [44,45]. Publication of results were not a common practice in the early years of the department. Guidelines on student-faculty collaborations may be reviewed so that researches of students who graduate may still be published by faculty advisers, with consent from the student author. This requires improved copyright guidelines, interventions such as writing courses [46], and faculty going the extra mile to become writing coaches who will commit to a regular writing session with the students [47]. This could be done by establishing student journals [48], similar to the UBC Medical Journal [49] to support students in their first attempt to publish.

Recommendations

The conduct of undergraduate researches is vital, both at the individual and institutional level. Aside from enriching the students' learning process and continuously affecting their personal and professional lives [50], undergraduate researches support institutional research thrusts given the workload of faculty members trying to juggle instruction and research functions. Especially in medicinal plants research where experiments are vital in ensuring quality of research outputs, a collaborative research between a faculty member and undergraduate student is necessary. Thus, the following recommendations are outlined:

1. establish a research center solely focused on medicinal plant studies, which should be provided with adequate funding and other institutional support;
2. include medicinal plants research, along with indigenous knowledge, in the institution's research thematic areas;
3. activate IACUC and other related committees to oversee proper use and care of experimental animals and safety of researches;
4. institutionalize the submission of voucher specimens to a reputable herbarium to support plant taxonomy and conservation; and
5. improve publication rates of faculty and students, starting with student or institutional journals.

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