INTRODUCTION

In*flores*cence: Mapping the Development of Interdisciplinal Studies on the Sago Palm in the University of the Philippines

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inflorescence *noun* | in·flo·res·cence | \ˌin-flə-ˈre-sᵊn(t)s\

1 **a :** the mode of development and arrangement of flowers on an axis
b : a floral axis with its appendages; also : a flower cluster

2 **:** the budding and unfolding of blossoms : flowering

New Latin *inflorescentia*, from Late Latin *inflorescent-*, *inflorescens*, present participle of *inflorescere* to begin to bloom, from Latin *in-* + *florescere* to begin to bloom — more at FLORESCENCE

First Known Use: 1760 (*Merriam-Webster Dictionary*)

It began with, quite literally, the smallest of things.

In 2004, Dr. Dulce Flores, an associate professor of chemistry and food science at the University of the Philippines Mindanao, first described a microbe, *Enterococcus faecium* DMF78, a bacterial strain she isolated from *puto* or rice cake, a popular snack across the Philippines (Flores et al. 2004). Among the properties Flores discovered in the activity of the microbe was its ability to produce lactic acid as a by-product in metabolizing, or consuming, starch (Shibata et al. 2007).

Lactic acid, more popularly known as a component in hygiene washes, actually has many other important applications that makes worldwide demand for this substance high. Flores noted how the bacteria she discovered could provide a more efficient way of obtaining lactic acid, given that the bacteria did not need to be placed in a highly controlled environment to produce it: simply place the microbe with a starch source to sit overnight, at room temperature, and the next day will see a quantity of lactic acid.

After her discovery of *E. faecium* DMF78, Flores next asked this very important question: *What kind of starch does my microbe like to eat?*

From Flores's recollections, this question allowed her to do more of a much-enjoyed pastime that led her to the bacteria in *puto* in the first place—that is, visit markets and explore the various sources of starch that were locally available. She experimented with different starches such as rice and root crops and found that sago starch—commonly derived from the palm *Metroxylon sagu* Rottb.—was, as she put it, "the microbe's favorite."

It was a long road for Flores before this trailblazing discovery and her life-long love affair with the sago palm. She received her undergraduate degrees in education (graduating cum laude) in 1967 and in chemistry in 1977 from the University of San Carlos, Cebu City;

FIGURE 1 Dr. Dulce Flores interviewed by Dr. Antonio Moran during filming of the "Dulce Flores and Sago" documentary project in 2014. PHOTOS BY A.M. RAGRAGIO

her masters in food science from the University of the Philippines Los Baños in 1987; and her PhD in chemistry from Tokyo University of Agriculture, Japan, in 1993. She has worked as a researcher for the National Institute of Microbiology and Biotechnology (BIOTECH) in UP Los Baños for many years, studying plant biochemistry and starch biotechnology, which ultimately led to her passion for research on the sago palm, a passion she continued to pursue when she relocated to Davao City to teach in UP Mindanao in 1996.

Flores noted that sago starch was little appreciated beyond being an ingredient in quaint traditional delicacies. She observed that "[i]n the Philippines, except for a few sporadic scientific investigations on this palm, there has been virtually no known effort from the government or research groups to highlight the benefits and prospects of this 'forgotten palm'" (Flores 2008). She saw the need to explore starch diversification to produce value-added products, particularly in biotechnological applications in tandem with the bacteria. Moreover, she was also conscious that a steady supply of sago from sago-producing environments and communities would be needed for potential future commercial applications, thus expanding the research horizons to include ecological and social studies.

It was in this way that sago emerged as the unwitting focus of a pioneering and a more-than-a-decade-long interdisciplinary research program in UP Mindanao, which has grown tremendously out of its almost-accidental biotechnological origins. Nevertheless, it is apparent that even at this incipient phase of sago research, Flores had already broadly outlined the general themes that would characterize sago studies and confront the researchers that came after her, namely, food sustainability, commercial applications toward local industrialization, and the need for international collaborations, especially with our Southeast Asian neighbors.

Sago in the Natural and Applied Sciences

Since her move to UP Mindanao from Los Baños, Flores continued her work on the sago palm, focusing on the screening, isolation, characterization, and identification of starch-fermenting lactic acid bacteria from indigenous fermented foods, production of bacteriocin (bacteria-produced proteins that have antibacterial functions against other strains) (Flores and Silva 2003), and documenting the indigenous plant starch sources in Mindanao.[1] In

1. Flores DM. 2001–2003. Biotechnological utilization of sago starch into high-value products. [Research project]

2003, she received a grant from the Japan Society for the Promotion of Science, which allowed her to continue work on sago in a "properly furnished" laboratory in Kyushu University, Japan, and to travel to Indonesia and Malaysia to expand her network of researchers doing work on the sago palm.

Following Flores's lead, her colleagues working in the natural and applied sciences took up the challenge in accordance with their respective expertise. Some continued research on the industrial uses of sago as high-fructose corn syrup[2] and gelling agent in tissue culture medium.[3] Others focused on ecological studies of Mindanao wetlands such as the Agusan Marsh in Northern Mindanao[4] where most sago are sourced in the island, which provided baseline information on *M. sagu* and its surrounding environment, as well biological studies on sago reproduction (Rasco and Cutab 2004). Studies on other species associated with the palm such as fungi and insects[5] (Abad et al. 2004), as well as pathogens and microbes in marshland soil,[6] aimed to minimize the potentially adverse effects of transplanting sago into different environmental settings. A different set of challenges stem from exploring the possibility of growing sago in areas away from the palm's natural habitat (see Rallos et al. 2007; Abad et al. 2006; Navarrete and Dejeto 2004).

By 2008, the College of Science and Mathematics formally identified the sustainable utilization of Mindanao bioresources and biodiversity conservation as their research thrusts under the Comprehensive Mindanao Studies Program (CMSP), with the sago palm as the focal commodity. The aim of the college was to tap ignored or underutilized bioresources in the island for economic utilization via biotechnology and processing into high-value products. While this is the main goal, environmental concerns are taken into account in tapping this bioresource as other fauna and flora of ecological importance exist in the ecosystems where the commodity is found. Most of the funding for efforts under the CMSP is from the Philippine Council for Advanced Science and Technology Research and Development (PCASTRD) of the Department of Science and Technology (DOST).

Project I. (with Obsioma VP) Direct fermentation of sago starch to lactic acid by a local *Lactococcus* strain; Project II. (with Silva GP) Bacteriocin production using lactic acid bacteria from local fermented food products; Project III. (with thesis students) Documenting the indigenous plant starch sources in Mindanao. Funded by the UP Mindanao research grant. [Data on research projects are from the database of R&D productivity indicators of the Office of Research, UP Mindanao—Ed.]

2. Fundador NGV. 2004–2006. Production of high fructose corn syrup from sago starch using immobilized glucose isomerates. [Research project] Funded by the UP Mindanao research grant and UP System Creative Work and Research Grant (CWRG).

3. Duran VA. 2005–2007. Assessing the potential of sago starch as a gelling agent in tissue culture medium. [Research project] Funded by the UP Mindanao research grant.

4. Talde CM, Bastian ST Jr. 2001–2004. Wetland resource management: focus on sago research. [Research project] Funded by the UP Mindanao research grant; Ibañez JC. 2003–2005. Are sago palm stands a critical habitat for endemic wildlife? A preliminary investigation on the potentials of sago (*Metroxylon sagu*) in the rehabilitation of marginal swamp forests and as habitat corridors for wildlife. [Research project] Funded by the UP Mindanao research grant and UP Center for Integrative and Development Studies.

5. Abad RG. 2004–2005. Pathogenic fungi and herbivorous invertebrates associated with sago (*Metroxylon sagu* Rottb.). [Research project] Funded by the UP System CWRG.

6. Rallos LEE, Colcol JF. 2003–2005. Plant growth promoting rhizospheric nitrogen-fixers of the sago palm (*Metroxylon sagu* Rottb.) growing in Agusan Marsh. [Research project] Funded by the UP Mindanao research grant and UP System CWRG; Rallos LEE. 2005–2006. Sago palm rhizospheric bacterial isolates: Are they plant-growth promoting bacteria? [Research project] Funded by the UP System CWRG; Vernaiz MAC. 2007–2008. Are rhizospheric bacteria from sago palm plant growth promoting microbes? Part II. Characterizing biochemical capabilities of the isolates. [Research project] Funded by the UP Mindanao research grant.

Different departments of the college were tasked with studying various aspects of the palm, and the ensuing researches formed the Sago Biotech Program: Phase 1. Researchers under the Department of Biological Sciences and Environmental Studies focused on conservation of sago bioresource, with studies on propagation of sago palm using tissue culture,[7] varietal verification of sago species,[8] improving survivability of sago in the field,[9] potential pests and pathogens of sago,[10] rhizobacterial isolates from sago[11] (Nemenzo et al. 2012), animal species associated with sago in wetland ecologies,[12] and other related studies.[13] Being Flores's departmental unit, the Department of Food Science and Chemistry focused on extracting sago starch[14] and converting sago starch into high-value products such as lactic acid,[15] ethanol,[16] and biodegradable plastics.[17] Meanwhile, the Department of Math, Physics, and Computer Science focused on determining the spatial distribution of sago and the approximate mass of this bioresource in Mindanao through remote sensing technology.[18]

To showcase the university's work on the palm, the university in 2008 published a special issue of its research journal *Banwa* dedicated to sago. Edited by Dr. Eufemio Rasco Jr. (2008), this volume contained original research on the morphology and reproduction of the palm (Rasco and Cutab 2008; Rasco et al. 2008) and organisms associated with the palm (Abad et al. 2008a; 2008b). The issue also featured a review article by Flores (2008) that summarized the versatile applications of sago and its starch—from being a staple food to raw material for industrial products and carbon sink for climate change mitigation. This received the Most Outstanding Monograph Award from the National Academy of Science and Technology in 2009.

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7. Novero AU. 2007–2008. In vitro clonal propagation of sago palm (*Metroxylon sagu* Rottb.). [Research project] Funded by the UP Mindanao research grant; Novero AU. 2008–2010. Micropropagation of sago palm. [Research project] Funded by DOST-PCASTRD.

8. Bastian ST Jr. 2008–2009. Molecular varietal verification of sago species (*Metroxylon sagu* Rottb.) vis-à-vis starch yield. [Research project] Funded by DOST-PCASTRD.

9. Mantiquilla JA, Bayogan ERV. 2009–2010. Improving survivability of sago suckers as planting materials. [Research project] Funded by the UP Mindanao research grant.

10. Abad RG. 2008–2009. Biological control agents for potential pests and diseases of cultivated sago: A morpho-molecular characterization of palm weevils associated with sago. [Research project] Funded by DOST-PCASTRD.

11. Bayogan ERV, Rivero GC. 2008–2012. Plant growth promoting factors from rhizobacterial strains of sago palm. [Research project] Funded by DOST-PCASTRD.

12. Ates FB, Talde CM. 2008–2009. Anurans and meiobenthic assemblages associated with sago in the wetlands. [Research project] Funded by DOST-PCASTRD.

13. Novero AU. 2008–2010. Cloning and expression of raw starch-digesting amylase gene in *E. coli.* [Research project] Funded by DOST-PCASTRD.

14. Flores DM. 2009–2010. Starch extraction studies, functional properties, and food application of sago flour. [Research project] Funded by the UP Mindanao research grant.

15. Flores DM. 2008–2009. Direct lactic acid fermentation of sago starch using a novel amylolytic lactic acid bacterium. [Research project] Funded by DOST-PCASTRD.

16. Flores DM. 2008–2010. Ethanol fermentation of sago starch using raw starch-digesting amylases: 1-L fermentor scale. [Research project] Funded by DOST-PCASTRD.

17. Fundador NGV. 2007–2008. Biodegradable plastics with sago starch. [Research project] Funded by DOST-PCASTRD.

18. Calag VB. 2008–2009. Assessing the sago bioresource in Mindanao using remote sensing technology. [Research project] Funded by DOST-PCASTRD.

By the end of 2011, Flores has started expanding her formal inquiry on the process of sago palm starch extraction from a predominantly laboratory-oriented to an ethnographic one. She started the video documention of the dry method of sago starch extraction native to her hometown of Argao, Cebu.[19] In chapter 1 of this monograph, Flores reports on this novel dry process, which is further expanded with laboratory studies investigating the chemical properties of sago flour produced using this process in comparison to flour produced using the typical wet process found in Mindanao.

A major stage in sago research of the college was carved in early 2011 when Dr. Reynaldo Abad, the former dean, led the college in packaging a proposal for DOST entitled "UP Mindanao Biotech Program, Phase 2: Conservation and Sustainable Utilization of Indigenous Bioresources in Mindanao: Sago Palm." In its raw form, the outlined titles in this new package of projects have already plotted the major areas of work that the college later pursued.

With funding from the Philippine Council for Industry, Energy, and Emerging Technology Research and Development (DOST-PCIEERD), the proposal was retooled, and this resulted in various researchers from the college being involved in three big programs, namely, (1) Sago Resource Utilization for a Sunrise Bioindustry in Mindanao; (2) Sago Bioresource Assessment for Sustainable Industry Utilization using Remote Sensing, Geospatial and Suitability Analysis (with UP Diliman and Caraga State University); and (3) Sago Bioresource Conservation and Flour Production. This infusion of government funds for research further strengthened the sago program in the university, expanding previous researches on novel enzyme-based ethanol and lactic acid production, sago palm tissue culture, sago flour production for food and nonfood uses, and bioresource assessment of sago areas in Mindanao.[20]

Various chapters of this monograph present results of the sago bioresource assessment program. In chapter 4, Engr. Jojene Santillan (formerly of UP Diliman and now with Caraga State University) reports on his research team's work using data from satellite remote sensing and ground surveys to come up with more reliable estimates of the most recent location and distribution of sago palms. In chapter 5, Leo Estaña and his research team assessed the potential yield and bioresource availability of sago palms in Mindanao using data from Santillan's study and concluded that the current densities of palms in the area can sustainably support a sago industry. Moving beyond utilizing naturally existing stands, Engr. Meriam Makinano-Santillan (Caraga State University) reports in chapter 8 how she and her research team found areas in the Philippines that are biophysically and bioclimatically suitable for sago palm propagation.

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19. Flores DM. 2011–2012. Documenting the indigenous process of sago starch extraction from sago pith: Argao dry process. [Research project] Funded by the UP Mindanao research grant.

20. The following are the projects under the three programs funded by DOST-PCIEERD (formerly PCASTRD): (1) Novero AU, Tolentino JHG. 2012–2014. Project I.1. Cloning and expression of raw starch-digesting amylase genes from *Saccharomycopsis fibuligera* and *Saccharomycopsis bubodii* for direct ethanol fermentation. (2) Fronteras J. 2012–2014. Project I.2. Ethanol fermentation of sago starch using raw starch-digesting amylases: Strategies for production without the costly starch pre-treatment. (3) Flores DM. 2012–2014. Project I.3. Direct lactic acid fermentation of sago starch without the costly starch pretreatment using *Enterococcus faecium* DMF78: Pilot plant scale costing of the process. (4) Oponda NB (2012–2013); Acosta JD, Estaña LMB (2013–2014). Project II.1. GIS-assisted assessment on the potential yields and bioresource availability of sago for sustainable industry utilization. (5) Novero AU. 2012–2014. Project III.1. Clonal propagation of sago palm. (6) Flores DM, Dacera DdM. 2012–2013. Project III.2. Flour production from sago for food and non-food uses.

Over the years, UP Mindanao has continued to develop depth in investigating the use of technologies like tissue culture to propagate sago, and this has become a major branching of the college's biotechnology program. Work on this area was initiated by plant molecular biologist Dr. Annabelle Novero (see Novero et al. 2010; Novero 2012; Novero and Jamiri 2012; Bargamento et al. 2013; Labrador et al. 2014), who later became dean and helmed the college's research program. She has mentored other researchers to pursue work on this area, focusing on initiation of callus and somatic and zygotic embryos[21] and improving viability and germination of the palm.[22] Her more recent work has also expanded into epigenetic mechanisms to control expression of genetic characteristics of sago palms, most notably the presence of spines on the palm.[23]

Building on the previous work done on sago tissue culture, Aileen Grace Delima, who specializes on plant genetic resource conservation, continued work on investigating various techniques for sago propagation in vitro (Delima 2015; Delima et al. 2015); and in chapter 7, she offers a review of the various challenges in the traditional sago palm propagation that necessitates research on alternative means to propagate the palm.

Other projects on sago from the sciences include investigating the microbial property of sago starch blend films to improve food safety[24] and the feasibility of utilizing sago flour to improve the nutritional profile of selected food products[25] with the goal of contributing to food security and poverty alleviation in Mindanao by tapping an underutilized food resource and creating technologies that can be easily transferred to the community.

The Anthropology of Sago

In 2009, after eight years of slow but steady knowledge accumulation of the biological and chemical properties and applications of sago, the Department of Social Sciences, under its anthropology program, entered the scene. The Anthropology of Sago research program[26] was conceptualized by the department in response to Flores's urging that the social aspects of sago production must likewise be investigated, as she did in her own hometown of Argao. This aligned neatly with the environmental anthropology thrust and a bent toward research on Lumad (Mindanao indigenous peoples) by the department, given that the largest sago forest areas are found in Mindanao and within the ancestral domain of the Manobo.

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21. Acaso JT, Novero AU. 2013–2015. Initiation of callus from sago palm shoot explants and embryos. [Research project] Funded by the UP Mindanao research grant.

22. Delima AG, Novero AU. 2014–2015. Enhancing sago palm (*Metroxylon sagu* Rottb.) seed germination through various techniques. [Research project] Funded by the UP Mindanao research grant; Delima AG, Novero AU. 2014–2016. Enhancing Sago Palm (*Metroxylon sagu* Rottb.) Seed Germination through Various Techniques. [Research project] Funded by the UP Mindanao research grant.

23. Novero AU. 2011–2012. DNA methylation profiling of sago palm. [Research project] Funded under the UP System CWRG. Novero AU. 2015–2016. Qualitative investigation on the differential expression of genes associated with spine formation in sago palm using TR-PCR. [Research project] Funded by the UP System ECWRG.

24. Fundador NGV. 2015–2017. Investigative study on the antimicrobial property of sago starch blend films with nisin. [Research project] Funded by the UP Mindanao research grant.

25. Alviola JNA. 2015–2017. Utilization of sago flour to improve nutritional profile of selected food products. [Research project] Funded by the UP Balik PhD Grant.

26. Paluga MJD, Clamonte V Jr, Labastilla S, Varquez JG Jr. 2009–2010. Ethnographic and comparative study of sago-related practices and folk narratives among wild-sago-using communities of Northeastern Mindanao. [Research project] Funded by the UP Mindanao research grant.

The earliest incarnation of this research program[27] were two anthropology field schools conducted in 2010 (in Bunawan, Agusan del Sur) and 2011 (in Veruela, Agusan del Sur), which resulted in several supervised student researches. The major findings of the sago field schools revolved around these major anthropological concerns: (1) documentation of traditional sago processing methods and other economic activities in the marshlands, (2) the cultural geography of sago, and (3) ancestral domain governance of the sago forest as contested commons.[28]

One of the student and faculty researches include the comparison of sago extraction technology of Manobo, Muslim, and Bisaya peoples, noting several similarities in tools and steps in the extraction process, as well as differences in seasonality of sago use, and views of sago as food source that stem partly from their respective spiritual beliefs.[29] These differences opened up the possibility of considering "ways of doing" as an identity marker or at least as a reflection of the preferred values of each group. Aside from sago extraction, various economic activities in the area were studied, such as seasonal fishing,[30] rice farming,[31] household gardening,[32] and thatching,[33] so as to further entwine this concern about a singular palm to its human community settings.

Based upon a heuristic framework[34] designed during the 2010 field school, several sago forest "folk maps" using the said technique were produced, which was analyzed by comparing global positioning system points "mapping" with the "wayfinding" folk-maps of knowledgeable informants.[35] This direction was subsequently pursued with additional ground-truthing and crucial ethno-ecological details of the Bunawan sago forest place-names (Varquez 2015a; 2015b). This approach has resulted in a deeper understanding of the cultural geography of the sago marshland and its surrounding environs from the emic perspective. A similar line was pursued in the effort to uncover local classifications of plants

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27. Note that the first research on sago in the department was an undergraduate thesis by RAE dela Cruz (2003), which was subsequently written into a paper in 2009 but remains unpublished: Campado AV, dela Cruz RAE. 2009. Sago to the Manobos of Cabanbanan, Bunawan, Agusan del Sur: From a gathered resource to a marketable Commodity. [Unpublished paper] Unreferenced.

28. See Paluga MJ, Cabazares J, Salubre J, Alaba M, Abadesco E, Trono W, Buenacosa K, de Castro SM, Cagula RR, de Castro MD. 2013. Notes on the history and key findings of the field school–based 'anthropology of sago' project of DSS (2007–present). [Unpublished working paper] Unreferenced.

29. Adovas AC. 2010. Comparative study of the technology of sagu (*unaw*) production in Barangay Mambalili, Bunawan, Agusan del Sur. [Unpublished manuscript] Unreferenced.

30. Alaba MC. 2010. Pamamaraan ng pangingisda ng mga Manobo ng Agusan Marsh. [Unpublished manuscript] Unreferenced.

31. Trono WKL. 2010. Material culture of rice-paddy farming of Mambalili; Bermoy LRR. 2010. Pamumuhay sa palayan: Pagsusuri sa dinamika ng isang pamayanang agrikultural, isang pag-aaral na naglalarawan sa Barangay Mambilili, Bunawan, Agusan del Sur; Juaton JCD. 2011. Bacay Dos beyond the subsistent time: A study on the changes in the livelihood of the Manobos of Agusan del Sur. [Unpublished manuscripts] Unreferenced.

32. Buenacosa KH. 2010. Traditional gardens: A seasonal contribution of women in the household. [Unpublished manuscript] Unreferenced.

33. Cabazares J. 2015. Sani: Sago palm thatching practices among the Manobos and migrants along the sago forests of Agusan del Sur. [Unpublished manuscript] Unreferenced.

34. The 'heuristic schema' was first given as a paper presentation. Paluga MJD, Abadesco EA. 2010. Heuristic schemas for an anthropology of sago (*Metroxylon sagu*) in Agusan marsh, Agusan del Sur, Mindanao. Paper presented during the Mindanao Conference on Issues in Development, Davao City, 8–9 November 2010.

35. Abadesco EEC. 2010. Pagstruktura ng kayumbiahan: Ang kayumbiahan bilang gawang kapaligiran (built environment). [Unpublished manuscript] Unreferenced.

and animals using linguistic data.[36]

In a study about the sago forest as a common-pool resource and its management as under both traditional and nontraditional political institutions, the effects (both possible and transpired) of the involvement and/or entrance of nonlocal, nongovernment entities in the ancestral domain, particularly of NGOs and private firms, were examined.[37] Meanwhile, traditional and recent methods of dealing with conflict in a community of mixed Bisaya and Lumad in the area were also investigated.[38] Studies of folk religion and spiritual practices with respect to specific ecological zones (marshland, farmland, etc.) revealed the Agusan landscape not just as a source of livelihood, subject to differing definitions of ownership, but as a spiritual landscape imbued with intangible values as reflected in ritual, taboo, and oral literature.[39]

Since 2011, follow-up field visits were conducted by faculty and students of the department.[40] Further inquiries about sago extraction and usage in other areas and among other groups were made during other occasions of fieldwork.

This departmental research program opened up important approaches and themes in doing human-plant relations as an aspect of *banwa* studies, which highlights human-nonhuman interactions in space and time. All told, this program may be considered one of the longest-running research themes of the department whose horizons, as of now, continue to generate potential expansive directions.

The latest social science contributions in this respect are included in chapters 2 and 3 of this volume. The two studies of Andrea Malaya Ragragio and Myfel Joseph Paluga build on what they think are the two key findings of previous fieldworks: the upland-lowland distinction among the Manobos in the kind of palm they exploit as a source of starch (which they all call by the same name *natok*) and the importance of studying the different indigenous methods of extracting starch given the variations in historical and environmental settings among native groups of the archipelago. Their comparative approach highlights local innovation (in the case of specific technologies) and cultural interaction (in the case of shared technologies) among indigenous sago-exploiting communities.

Future direction of research include creative ethnohistory and experimental anthropology, which will use the power of fiction and the imagination to flesh out recent anthropological findings related to sago into a creative narrative.[41]

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36. Rebucas ADD. 2010. Ethnobiology: The classification of plants and animals in three socio-ecological areas. [Unpublished manuscript] Unreferenced.

37. Salubre JC. 2010. Ang pamamahala at pagplano ng Bunawan ancestral domain sa konteksto ng kalumbiahan bilang isang common pool resource. [Unpublished manuscript] Unreferenced.

38. Cagula RR. 2011. Conflict and harmony: Political organization and conflict resolution mechanisms of Manobos of Bacay Dos, Veruela, Agusan del Sur. [Unpublished manuscript] Unreferenced.

39. De Castro SMS. 2010. Spiritual practices in different socio-economic areas of the Manobo in Mambalili, Bunawan, Agusan del Sur; Dicto CMYJ. 2011. Socio-ecological implications of the spiritual technology of the Manobo of Bacay Dos, Veruela, Agusan del Sur; Dumayag F. 2011. Folk Christianity in a community composed of the Manobo Christians and the immigrant Christians as manifested in Bacay Dos, Agusan del Sur; Mejia JA. 2011. Of voices and songs, the Tud-om of Bacay Dos: Its words, meanings, and its gradual decline. [Unpublished manuscripts] Unreferenced.

40. Ragragio AM. 2014. Ecological anthropology of sago. [Research project] Personally funded.

41. Bengan JB, Ragragio AM, Paluga MJ. 2016. *Natok* in the time of distress: Creative ethnohistory and experimental anthropology of sago. [Research project] Funded by the UP Mindanao research grant.

Economics of Sago

In recent years, as established sago research directions continued and new areas of inquiry were added, the sago program of UP Mindanao began investigating the economics of sago and how to establish commercial-scale production of sago-based products.

In 2010, the School of Management initiated a market study to investigate market potential for sago as alternative source for starch and lactic acid.[42] This was further scaled up in 2013 with an evaluation research designed to assess the existing supply chain for sago in the Philippines and to identify areas for improvement, which was funded by the Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development (PCAARRD) of DOST.[43]

Reporting on the results of their research team's study in chapters 6 and 9, Nikko Laorden and Thaddeus Acuña, respectively, determined that while there is no robust value chain of sago products at present, there is high market potential for sago and its derivatives (especially in the form of lactic acid) in the Philippines—extrapolating from starch imports and secondary data from Asian markets—and that establishing a sago plantation and building community-based enterprises in the Agusan Marsh in Mindanao are financially viable. However, they caution that since this is the first time such a project will be undertaken in the country, strong government support is needed in the proposed strategic development plan that lays down the framework by which such an industry can be nurtured.

Branching Lines of Pursuit: Alternative Technology, Sustainability, and Policy

As can be seen above, the Department of Food Science and Chemistry is a nodal department in all the studies done so far. Setting the direction toward mechanization, Flores[44] submitted the design for a complete set of sago flour mill equipment as a major accomplishment. This would be, as reported, "the first of its kind in the Philippines." Also, its mobile design (the entire equipment can be set on a trailer truck) would allow it to be moved to different sago-producing areas, with the recognition that not only are sago areas dispersed but sago-harvesting communities also rarely have the resources for the bulk transport of logs if a permanent demo plant had been built instead.

Additionally, the study's recommendation is also of interdisciplinary interest: (1) a marketing aspect via a "project development area" in a proposed Food Pilot Plant Facility "for students who wish to scale up their product dev[elopment] output and do some consumer testing and market testing, to include a pilot bakery area" and (2) a vintage anthropological aspect with the establishment of a "sago museum," envisioning "that all research output and documents can be housed in this area."

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42. Concepcion SB, Montiflor MO, Hualda LAT. 2010–2012. Market study for sago (*Metroxylon sagu* Rottb.): Market potential for sago as alternative source for starch and lactic acid. [Research project] Funded by the UP Mindanao research grant.

43. Concepcion SB, Laorden NL, Acuña TR, Fedillaga, AJA. 2013–2015. Supply chain improvement of sago in selected regions in the Philippines (Phase 1: evaluation research). [Research project] Funded by DOST-PCAARRD.

44. Flores DM, Dacera DdM (2012–2013). Project III.2. Flour production from sago for food and non-food uses [Research project]. Funded under DOST-PCIEERD. [Quotes from the submitted terminal report.—Ed.]

Through support from the UP Center for Integrative and Development Studies, a new study, which focused on two new directions toward "sustainability" and "policy," was conducted.[45] The study recommended the inclusion of *M. sagu* in the list of endangered species due to the conversion of wild sago stands "into roads, commercial areas, rice fields and other land uses that they [locals] perceive to have greater economic returns" and reinforced by "lack of awareness on its utilization."

With perceptive insight, the study highlighted three important areas also pursued in the context of social science/anthropology field investigations: (1) the importance of doing "initiatives of local communities involved in sago conservation," (2) the dissemination and duplication of "success stories on sago conservation," and (3) the "need to revisit the places where LGUs (local government units) support the need for a village-scale sago flour processing facility" to actualize the mobile sago flour mill.

While there are limits in the preceding study (in particular, minimal input from studies from other relevant departments in the university), the three areas listed above are certainly highly sensible proposals for thematic branching coming centrally from food science practitioners. Moreover, efforts to integrate the three colleges of UP Mindanao have, at this point, already taken off the ground.

Coming Together

So that the different UP Mindanao researches can come together toward building an interdisciplinary program, the Office of Research organized two symposia on the sago palm: "Rediscovering the Forgotten Palm: A Symposium on Sago (*Metroxylon sagu* Rottb.)" on 22 February 2012 and "Inventory of Sago Stands in the Philippines and Campaign for Conservation and Utilization" on 15 February 2013. These two symposia became a venue for researchers from different disciplines to share their results, as well as inform the public about the importance of the palm for ecology and livelihood as part of the university's advocacy. The second symposium on sago was also significant as it brought together researchers working on the palm from other institutions such as Aklan State University, Caraga State University, and Visayas State University and coincided with the launching of the DOST-PCIEERD–funded pilot-scale sago flour mill envisioned by Flores.[46]

Because of her tireless efforts, Flores has also connected Philippine research on sago with the rest of the world. She became a country representative to the Sago Network for Asia and the Pacific (SNAP), which is a network of researchers and stakeholders from Japan, Indonesia, Malaysia, Thailand, Fiji, the Philippines, and Papua New Guinea who advocate the conservation, sustainable cultivation, utilization, and development of sago palm. In recognition for her pioneering role in sago research in the country, Flores was invited to deliver the keynote address entitled "Greening Asia: The Sago Invasion" at the 2nd ASEAN Sago Symposium at the Universiti Sarawak Malaysia in 2012.

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45. Dacera DdM, Blasing C. 2013–2014. Sago conservation: Towards a sustainable bioresource utilization. [Research project] Funded by the UP Center for Integrative and Development Studies. [Quotes are from the submitted terminal report.—Ed.]

46. Flores DM. 2010–2011. Establishment of pilot plant scale sago flour mill in the UP Mindanao Technology Business Incubation (TBI). [Research project] Funded by DOST-PCAARRD.

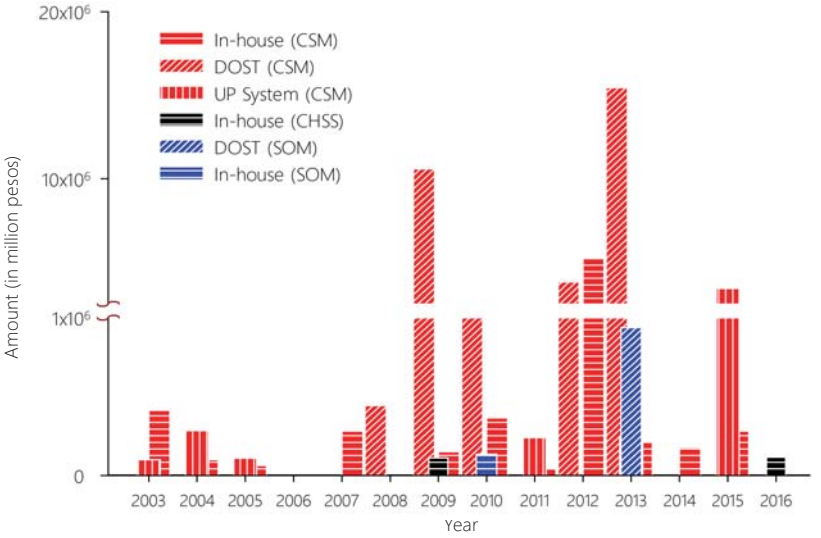

FIGURE 2 Funding for sago-related research by college and by source, 2003–2016

How to Evolve a Socially Relevant Research Program

All the above-mentioned pursuits highlight the generative value of the seminal interdisciplinal insights and authentic societal concerns of the late Dr. Dulce Flores, to whom this volume is aptly dedicated. If we count from 2001 when Flores started the train of research beginning with her discovery of *E. faecium* DMF78, the UP Mindanao research program on sago and related social and ecological aspects is now about fifteen years in duration. As the first comprehensive interdisciplinary research in UP Mindanao, what crucial learnings befitting a national university can we see from such toddler steps in inter-college undertakings?

First, there is a need to affirm institutional investment for research thrusts and themes that might not initially have a "rock star" standing in the so-called "global" scene in the sense of easily commanding big funding from the establishment and agencies. The initial interest on sago by Flores started as a marginal pursuit in the university, but after being given start-up funding—in the range of tens of thousands—from in-house and UP System sources and generating heterogeneous research output from 2004 to 2008, it soon attracted external funding sources (Figure 2). From 2009 to 2013, funding for sago studies started pouring into the university in the range of millions. We note that a year earlier, the university had wrapped up all its preceding studies from 2004 to 2008 into a publication (Rasco 2008), and this move certainly contributed to attracting support for previously an under-appreciated theme.

Second, the explicit inclusion of the complex sociopolitical realities in the stakeholder areas (especially on the theme of property relations actually operating in common-pool resource areas of Agusan Marsh) did not figure significantly in various drafted sago roadmaps, despite Flores's early realization of the importance of local empowerment for food sustainability and security. Finance-wise, the bulk of UP Mindanao funds for sago and sago-related researches came from DOST (85%), which poured money into the university starting 2009 (Figure 2). This post–start-up phase and DOST-driven funding went mostly to the College of Science and Mathematics (97%). In the package of projects facilitated

under such arrangements, one sees potential entry points for deepening social science concerns (such as calls for conservation), but these were not carried beyond the routine creation of "socio-economic profiles" or the usual side-glancing recognition of "improving communities" and "people's lives." Strongly put, there is a need, even for natural scientists, to do "social theorizing" within the very heart of everyday laboratory and field practices (Keller 2002). To cite a simple case, because practical indigenous folk use and categorizations of *sago* and *natok* (palm-sourced starch) did not figure in the preoccupations of natural scientists, one sees a highly tilted focus on the *Metroxylon* genus and almost none on the other palm types used by locals in sourcing their starch needs (see chapter 2).

Third, a synthetic study, beyond the patchwork phase of any cross-disciplinal program, of the major sago knowledge areas accumulated by the university has not been done up to this point. A more substantive synthesis and assessment of UP Mindanao's sago program is important as a prerequisite for developing finer post–Dulce Flores sago studies directions. Moreover, from an institutional perspective, it is also imperative to document the shaping of a more or less shared research theme despite theoretical and philosophical incongruences among individual participants. The interconnectedness of the sago-related researches reviewed here were actually pursued quite heterogeneously from the beginning. What we call a comprehensive "sago program" now is more a result of bricolage and only appears as a true coherent research program by retroactive glance.

For the big picture, American physicist, science studies scholar, and feminist Evelyn Fox Keller (2002), in what she labelled as the "life sciences," offers an exemplary historical analysis on how varied inter- and intra-disciplinal approaches and construals of the "object" and "ends" of research operate in specific university and laboratory settings. College research committees and the Office of Research can generate policies from such synthesis and documentation usable in refining institutional and conceptual frames nurturing real interdisciplinarity.

Toward National Industry Concerns and Organizing Community Enthusiasm

We recognize the many roles Dr. Dulce Flores played in getting a wide network of individuals, organizations, and institutions to go beyond the "givens." Her explorations of possibilities beyond the expectations from her scientific role led others to do their part. She challenged the strictures of bureaucracy that made work difficult for the scientist. At the same time, she observed the rigors of science that gained respectability for her research. Her community engagement and preference for the marginalized bridged the gap between laboratory interests and field social realities.

In our last conversations with Flores before her untimely death, what preoccupied her energies were already branching into a theme that we can readily recognize as social science and economics concerns proper: how to establish a local sago industry and how to organize folks and communities to support such an industry. Such spot-on insights are so admirable, more so because Flores was a biochemist and not a professional social scientist. Her concern is the right exemplar of true interdisciplinary spirit. Flores saw the need to start a viable, if small-scale, sago starch-processing industry and, eventually, upscale this for the production of high-end sago by-products.

After her retirement in 2015, Flores returned to her hometown in Argao, Cebu, and began organizing local women involved in sago starch processing and marketing in the Argao market. She sought to revitalize the appreciation of the local community for

their "lowly" bioresources so that folks will not end up being seduced by fashionable and easy-to-commercialize crops.

Broadly speaking, the present task is clearly on how to organize popular support and community enthusiasm for upscaled food (and nonfood) production and jumpstart nationalist bioregional industrialization founded firmly upon our native resources.

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