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Cover Photo

The *Betta splendens* Regan, 1910 or Siamese fighting fish is a freshwater fish native to Southeast Asia. Because of their diverse coloration, *B. splendens* are considered as one of the most popular aquarium fishes. Fish with unique color combinations as a result of selective breeding is highly sought by hobbyists. An individual which resembled Thailand's national flag was sold in an auction at more than a thousand US dollars. Photos courtesy of Dr. Ma. Mojena Gonzales-Plasus.

EDITORIAL

Research journals are the focal venue for sharing new knowledge, theories, and technologies geared toward the betterment of life. As borderless communication becomes more evident, sharing research results and conducting collaborative studies are not only the trend but also the way of life in the academe.

The Palawan Scientist, the official scientific journal of the Western Philippines University, continues to maintain its good reputation in the field, as evidenced by the Commission on Higher Education (CHED) Journal Incubation Grant in 2017 and its inclusion in the Clarivate Analytics database in 2019. Clarivate Analytics embodies the Web of Science Core Collection, where reputable journals are meticulously selected.

This first issue of the 14th volume of the Palawan Scientist covers a wide array of topics, from natural and social sciences. Notwithstanding the third pandemic year, ten interesting research articles in different fields such as education, fisheries, agriculture, engineering, and social science were accepted for publication. The said publications are authored by researchers from various institutions within and outside the Philippines.

As the world recovers from the Covid 19 pandemic, a clearer and more inviting path to conducting, writing, and publishing research is seen. Let this path inspire the researchers to produce research in natural science, social science, education, and others.

I firmly believe that research publication is one of the best heritage one can proffer for the next generation.

To the authors, my utmost gratitude for painstakingly adhering to the rigors of writing and editing your research. KUDOS FOR A JOB WELL DONE!

LIWAYWAY H. ACERO, EdD
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CONTENTS

A participatory action research (PAR)-influenced mentoring program for graduate students

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ABSTRACT

The study described a mentoring program of a state-funded research and its effects on research and reflective practices to graduate students. Participatory Action Research (PAR), designed as a methodical and program framework, engaged nine mentors (researchers of a state-funded research) and 29 graduate students (purposively invited) to training-based mentoring (workshops and field work), small group mentoring (within research cells), and peer mentoring (field work and software-aided coding analysis). Observations, mentors' narrations, and reflection journals extracted the experiences of the participants on the mentoring program. These reflections revealed that mentors and mentees learned many skills in the mentoring program. They had transformed challenges and difficulties (time management, field work) into learning episodes leading to reflection-in-action and reflection-on-action. They realized the importance of the theory-practice-reflection paradigm in all research endeavors. Hence, PAR-influenced mentoring helped develop their research skills. However, low engagement of the others may be due to time aspect, which may be looked into in a replicated study.

Keywords: collaborative practice and action, learning episodes, reflective-practitioner, research skills

INTRODUCTION

As a response to the Fourth Industrial Revolution era (FIRe) and as a new education paradigm that could deal with the new disruption and uncertainty brought about by the global pandemic, Education 4.0 (E4.0) envisions knowledge-based economy, high global competitiveness index, and provision for continuity of learning (OECD 2018). Two key drivers of E4.0 that influenced most countries are: 1) quality Science, Technology, Engineering, Mathematics (STEM) education, and 2) a strong system of graduate education (Current trends in higher education 2014). This new-found core of graduate education seeks to develop professionals who are both knowledgeable (advanced knowledge) and skilled (soft skills: capability to lead, a team player, and is terms of quality (Conchada and Tiongco 2015). Thus, efforts gear towards improving the graduate programs able to communicate). Thus, the thrust focuses on investing in graduate education and research infrastructure in the field of STEM, which most closely influence FIRe.

The 2017-2022 Philippine Development Plan (NEDA 2017) and quality assurance in higher and advanced learning (CHED 2012) assert a competitive higher education in the country. However, a low completion rate is still evident. Data shows that only 41% of the 656 state universities and colleges (SUCs), and 23% of the 1,643 private higher education institutions (HEIs) have graduate programs. A skewed distribution of post baccalaureate programs is observed where the majority of program offering clumped on Education (35%), Business Administration (9%), and Nursing (9%) (Ofreneo 2014). These top programs ranked fair or poor in through a holistic development of students as professionals and academicians.

The concept of mentoring is anchored on several theories and has begun inching in the graduate education system to assist students to overcome related challenges and difficulties. These theories include stable and transitional periods as keys of the life cycle (Levinson 1986) and developmental theory by Freud, Jung, and Erickson (Dominguez and Hager 2013). Additionally, Kegan's theory focuses on transformative learning where the learner encounters the distinct stages of experiences (McGowan et al. 2007). Kram (1985) espoused multiple and simultaneous mentoring methods (traditional mentoring, group mentoring, peer mentoring), exemplifying the importance of mentoring relationships. This relationship may be enhanced through Appreciative Inquiry (AI) that identifies and cultivates the best in people through the art and practice of asking questions that strengthens a person's capacity to apprehend, anticipate and improve their potential (Stratton-Berkessel 2020).

This study emphasized peer and group mentoring models (Darwin and Palmer 2009) which require the mentee to remain open to unlearning old skills and learning new ones. Compared to the traditional paradigm of knowledge transfer and wisdom-passing from old to young (Darwin 2000), the model supports Higgins and Kram (2001) concept of mentoring as a development of diverse mentoring relationships or networks, where the mentor acts as a guide (Zachary and Fischler 2009).

Apparently, graduate mentoring in most institutions in the Philippines differ from what universities in other countries perpetuate. In other countries, a supervisor is assigned to a graduate student upon acceptance to the graduate program. This early engagement of the graduate student in choosing the research topic helps widen the reach of the student to available expertise, research trends and standards (Tanhueco-Tumapon 2016). Thus, the current study details how the current model observed in most Philippine institutions of higher learning may be supplemented through research immersion of graduate students by voluntary engagement in research work of the university even before they enroll in their terminal courses. These supplements encourage expansion of the view and practice of mentoring in the graduate program to start from enrolment to graduation. This schema also provides students with the opportunity to expand workforce development as a responsibility of community engaged research groups (Arrieta et al. 2018) and may help improve students' perceptions of research (Kiersma et al. 2012).

While these theories highlight mentoring, a minority of such studies traces mentoring in the fields of graduate education in the Philippines. In other countries, the use of participatory action research (PAR) as a mentoring framework has been articulated on few occasions (Burke and Hadley 2018). PAR roots on the general attributes of Action Research (AR) that includes participatory character and reflective practice (Kemmis and McTaggart 1988), implemented in mentor education as part of professional development (Aspfors and Fransson 2015). PAR seeks to bring theory and practice, in participation with others, in pursuit of practical solutions to issues of pressing concern to people (Reason and Bradbury 2008) and equality of participants through participation and action (Morales 2019).

Mentoring goes beyond unlearning and learning. It may be attributed to a two-way development of Technological-Pedagogical-Assessment-Content-Knowledge (TPACK) system of mentor and mentees. TPACK describes the acquisition and demonstration of instructional experiences integrating content, pedagogy, and technology in establishing effective instructional practice and environment (Koehler and Mishra 2008), which exemplifies concrete steps of mentor education (Aspfors and Fransson 2015). AI puts a more human perspective on the program, being grounded on positive psychology focusing on the strengths of people and what works well in co-designing their future (Tocino-Smith 2020). Thus, this study designed a mentoring program for graduate education courses in Science, Technology, Engineering, Agri/Fisheries, Mathematics (STEAM) grounded on PAR framework and AI approach to supplement the course and research works of graduate students. Specifically, the study sought to: 1. Describe the mentoring program for graduate students; 2. Describe the development of collaborative practice or action; and 3. Identify the benefits of the mentoring program on research skills and reflective practice.

METHODS

Research Design

The study documented the mentoring program of a state-funded research on the TPACK of Philippine tertiary teachers of courses in STEAM. This state-funded research is a collaboration of 10 (7 state universities and colleges [SUC], namely, Philippine Normal University as Lead Institution, Mindanao State University – Iligan Institute of Technology, Polytechnic University of the Philippines, University of the Philippines Manila, University of the Philippines Los Banos, Batangas State University, and West Visayas State University, and 3 private universities, namely, De La Salle University , Jose Rizal University, and Manuel S. Enverga University Foundation) higher education institutions (HEIs) in the country. Figure 1 shows that the mentoring framework designed using multiple cases labeled as the research cells. The PAR was utilized as methodical framework to implement a mentoring program to volunteer graduate students. The framework emphasized the mentors' (researchers from the 10

collaborating HEIs) and the graduate students' varying roles that defined how the latter may have acquired meaningful and rich learning experiences and how the former emphasized working on AI to draw positive outcomes from the participants. Grounded on PAR and AI, the program supplements the formal supervisor-advisee paradigm to help the latter complete the research requirement of their graduate programs.

Components of Graduate Programs under the State-Funded Institution

Typically, graduate programs in the Philippines include several academic courses with thesis as a terminal course for degree completion. Table 1 shows the course distribution for graduate programs in the lead institution of the state-funded research.

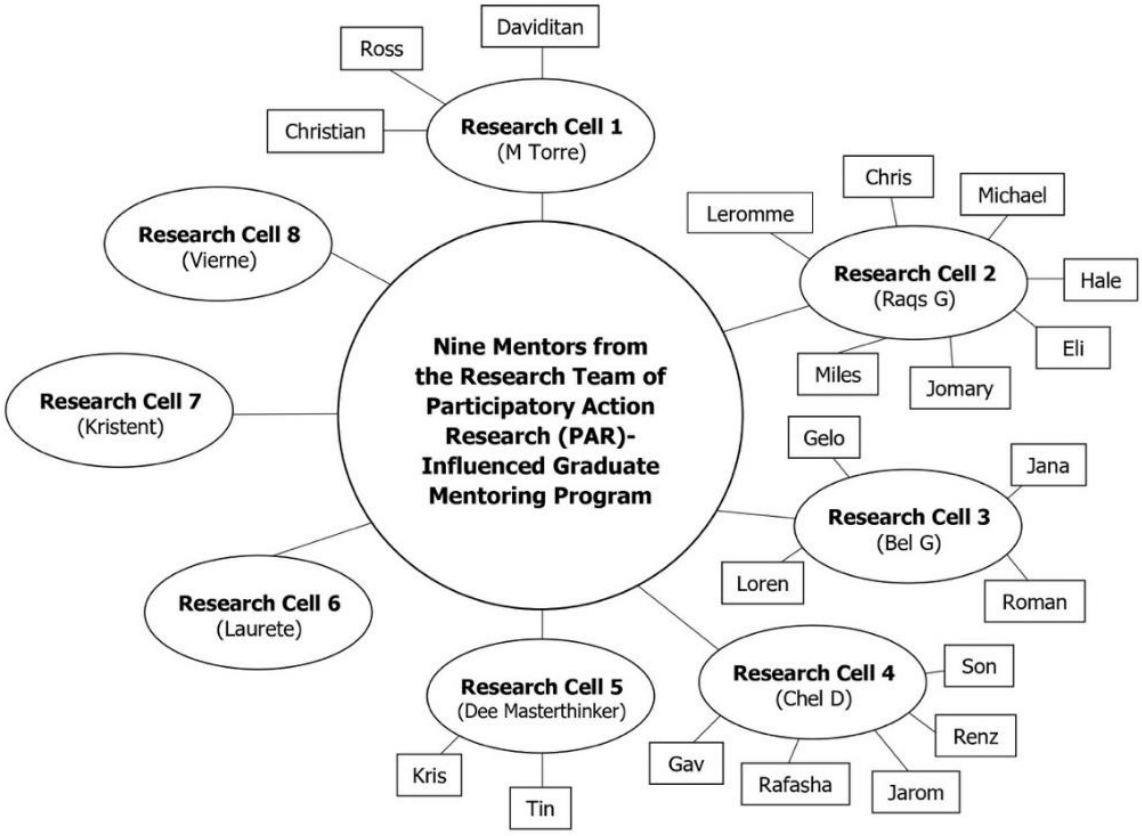

Figure 1. PAR-influenced mentoring framework for graduate education [names are pseudonyms]. The participants in oblong cell (senior mentees) were the first batch mentored by the nine researcher mentors, while in the rectangle cells (junior mentees) were the second batch mentored by the senior mentees.

Table 1. Program components and course distribution of graduate programs in the Lead Institution.

Components of the Programs	No. of Units	
	MA	PhD
Core Courses	9	12
Electives	3	6
Specialization Courses	18	24
Thesis/Dissertation	6	12
Foreign Language	0	6
TOTAL	36	60

Participants

A total of nine mentors (researcher from the 10 collaborating institutions of the state-funded research) and 29 graduate students (from the 10 collaborating institutions with names of the participants in this study as pseudonyms) were the participants of the mentoring program (Figure 1; Table 2). The first batch of mentees that included eight graduate students were purposively selected from the lead institution (Table 2).

The selection criteria include being currently enrolled in a dissertation course, working on his/her dissertation, and is a science/math education graduate student. These eight graduate students were labelled as the 'senior mentees' in Table 2 that defined each research cell in the study based on the methodical framework (Figure 1). These eight senior mentees had expressed their willingness to be part of the mentoring program (in their commitment forms) as supplement to the formal supervision by their official course (dissertation writing) supervisor. Permission was also sought for such an arrangement from the administration of the lead institution. The second batch of mentees included 21 graduate students who were in the different fields of STEAM education and mass communication programs and were active graduate students in any of the 10 collaborating institutions of the state-funded research. These second batch tagged as the 'junior mentees' in Table 2 populated five of the oblong cells (Figure 1). To qualify, the research team used the same selection criteria as aforementioned. They voluntarily signified their interest to join the mentoring program through the commitment form. They were also aware that the mentoring program is only ancillary to the formal supervision by their respective supervisors.

Instruments

Graduate mentoring reflection template/form. The form contained 11 questions. Four questions focused on the gained insights/learning of the mentees regarding their involvement in the mentoring program. The other seven questions highlighted their professional learning as they reflected on the whole research activity.

Graduate mentoring handbook. The handbook highlights salient information about how the mentoring program began, the pedagogical framework used in implementing the mentoring program, resources, policies, data collection instruments, guidelines for apprenticeship and the reflection templates by the mentees after their attendance in the different activities within the aforementioned state-funded research.

Table 2. Mentors and participants of the study in Participatory Action Research (PAR)-influenced mentoring program.

Nine Mentors from Research Team	Senior Mentees/Mentors in each Research Cells (PhD Science Education)	Junior Mentees	Program
Mentor 1 [M1] Mentor 2 [M2] Mentor 3 [M3] Mentor 4 [M4] Mentor 5 [M5] Mentor 6 [M6] Mentor 7 [M7] Mentor 8 [M8] Mentor 9 [M9]	Laureante	No junior mentees	
	M Torre	Ross	PhD Science Education
		Christian	MA Science Education
		Dadivitan	
	Raqs G	Leromme	MA in Information and communication
		Chris	MA in Mathematics
		Michael	
		Hale	
		Eli	MA Science Education
		Jomary	
		Miles	
	Bel G	Gelo	PhD Science Education
		Loren	
		Roman	
		Jana	
	Dee Masterthinker	Kris	MA Mass Communication
		Tin	
	Chel D	Gav	MA Science and Mathematics Education
		Rafasha	
		Jarome	
		Renz	
		Son	
	Kristent Vierne	No junior mentees	

Data Collection

Senior graduate mentees. The research team (mentors) documented the implementation of the entire mentoring program. In the implementation, recruitment of graduate student volunteers commenced before the data collection stage of the aforementioned state-funded research. The team first invited eight graduate students (senior mentees specified in Table 2) to join the meetings attended by the researchers of the aforementioned state-funded research, which also served as the invitees' immersion activity before their formal orientation to the project and to the mentoring program. After consent, the team oriented these senior mentees on the details and phases of the state-funded research. The team also sourced the challenges and difficulties the senior mentees are currently encountering in their research work and determined which research skills they want to learn or enhance. Upon consolidation of their needs, the research team presented the mentoring program from where these senior mentees could source knowledge and address their identified difficulties. Based on these needs, the research team conducted trainings on how to utilize the research instruments and discussed all requisites to data gathering (e.g. forms, allowances, allowable expenditures, government issuances on liquidation process and travel) procedures. There were free seminars/workshops (conducted in two to three days, in about five workshops) to train the senior mentees on interviewing, transcribing, and software-aided coding analysis. The research team (mentors) also provided the details of on-site transactions during the scheduled school visits for the state-funded research (data collection phase). Note that the program is not focused on assigning a specific mentee to a mentor, but each of the members of the research team is believed to be able to contribute as a mentor.

In order to develop collaborative practice and action and to identify the benefits of the mentoring program on research skills and reflective practice, the research team sent these senior mentees to actual field research works to collect country-wide data. The senior mentees were asked to accomplish the Graduate Reflection Template/Form for every assignment/deployment. They were also subjected to journaling technique as an approach to get an in-depth information about their experiences and challenges to describe and map the connections of their experiences in the mentoring program. Their journal entries were compiled for documentation and analysis.

Junior graduate mentees. Since the state-funded research requires nation-wide data, the team sourced new recruits (junior mentees) following the same selection criteria. For this second batch, the senior mentees served as immediate mentors to the junior volunteers (junior mentees). The senior mentees simulated all processes to formally orient the new batch of mentees (21, with eight active field researchers in the project). Here on, five research cells (Figure 1) were formed by assigning junior mentees to senior mentees. The senior mentees conducted tutorials (within their research cells) on how to administer interviews, classroom observation, and transcribe and implement software-aided coding analysis. With the PAR framework, the research team (mentors) coursed through assignments to field works to the senior mentees who communicate to their junior mentees within their research cells all pre-requisite data and processes needed for the conduct of the field work. The senior mentees also permitted the junior mentees within their research cell to work collaboratively with other members of the research team (mentors) and the other junior mentees who are assigned on the same field work. In detail, the research team involved the senior mentees in five out of seven components of the state-funded project. While the junior mentees concentrated on aiding the research team in terms of data gathering (three components of the project).

Data Analysis

The research team collated all graduate students' reflections through software-aided MAXQDA 2018 (VERBI Software 2019) coding analysis. Meticulous transcription, organization of responses, and abstractions were done on the reflections sourced from the accomplished templates. The transcripts were reviewed for errors and are read several times to immerse with the details of the interview before coding. Statements were broken into parts, gave prior meaning to codes, and noted the frequency of code occurrences. Finally, the research team assigned memos to the identified code system, to include the statements of the participants and finally crafted emergent themes from the constructed cluster of ideas.

RESULTS

The themes generated from the analysis match the three priori constructs: mentoring, collaborative action and practice, and benefits of the mentoring program.

Mentoring Program

The mentoring program trained six of the eight (75%) senior mentees for the first round of data collection (February to December 2018) and 21 junior mentees for the second batch of mentoring (January 2019 - March 2019) (Table 3).

The mentoring and training activities in each research cell enabled transfer of technology (interview strategies, data collection approaches, correspondence to other officials, coding and data analysis), and

upskilled members of each of the research cells through peer mentoring.

Collaborative Practice and Action

Table 4 shows the abstraction process done on the coded responses leading to the theme, collaborative practice and action. This abstraction process denotes that their challenging experiences (e.g. test of self-confidence) are stimulants of action and collaboration to counter these struggles.

Benefits of Mentoring Program on Research Skills, and Reflective Practice

Table 5 shows that the thematization of one of the prior constructs labeled as benefits of the mentoring program on research skills and reflective practice, emphasize three major categories that feature reflective-practice. As shown, the three categories cover a wide range of competencies of teacher-researcher which include technological capacity, research skills and professional and personal enhancement.

Table 3. Training and activities in mentoring program for senior and junior mentees.

Senior Mentors (pseudonyms)	Junior Mentees	Training and Mentoring Activities
Raqs G	7	• Batch 1 of Field work (February to December 2018) • Attendance to all the five 2-3-day workshop (be the research team on different topics in research) • Mentoring sessions of and constant communication (through face-to-face, short-messages, email or social media) with junior mentees • Batch 2 of Field work (January 2019 - March 2019)
Bel G	4	
M Torre	3	
Chel D	5	
Dee Masterthinker	2	
Laurente	0	• Field work (February to May 2018) • Attendance to all the five 2-3-day workshop (be the research team on different topics in research)
Kristent	0	• Attended 1 of 5 workshops • Had administrative tasks leading them to forego the program
Vierne	0	
TOTAL	21	

Table 4. Abstraction of coded responses of participants leading to the category, 'collaborative practice and action'.

Sample verbatim responses	Code (f=frequency)	Category	Theme
"My blood ran cold as I initially faced them, but eventually I realized that I have to establish confidence doing it." [M Torre]. "I stuttered and still felt nervous in asking questions during the interview." [Laurente] "In the interview phase, I had difficulty communicating the questions to the respondents since they have different perspectives or frame of reference, that is why I had to simplify the questions and give more probing questions."	Test of self-confidence (f=12)	Challenges to address	Collaborative Practice and Action
"They (students in the participating institutions) speak in their own language [dialect or L1], and their teacher allowed them, so I was not able to understand the content because of the language barrier" [Bel G].	Use of dialect (f=12)		
"Since my mentees were also employed and are also enrolled in their thesis writing, we all had difficulty in attending field works and scheduled meetings." [Dee Masterthinker]	Time management (f=4)		
"I think you should practice more on conducting the interview," [Mentor 1].	Practice (f=9)	Action and collaboration	
"I was happy to learn that I had mentees who successfully and actively participated in the field work." [Raqs G]. "I feel proud that I was able to contribute to improving the research skills of the members of my research cell, and this also developed me as a researcher and mentor as well" [M Torre].	Participate, contribute (f=4)		

Table 5. Benefits of the mentoring program on research skills, and reflective practice of the participants.

Sample verbatim responses	Code (f=frequency)	Category	Theme
"preparing, data gathering in a qualitative research instruments to be prepared. Instrument to be accomplished and signed prior to the interview like the consent form" [Dee Masterthinker]	Skills in qualitative research instruments (f=15)	Technical improvement	Benefits on Research Skills, and Reflective Practice
"workshops greatly help and develop my skills in coding qualitative data that easy"…We learned the nitty-gritty of qualitative research work. We get involved in transcribing and coding. I learned a lot. Memoing of the significant data, deciding what mother code can we make. These tasks helped us to be mindful of all the mother codes that we assign so that, it will be easier for us to do the coding and assigning daughter code" [M Torre]	Skills in coding (f=15)		
"It gears up my research skills and gives me confidence in doing qualitative research", "my skills as a qualitative researcher was honed" [M Torre]. "I was given the chance to apply the theoretical skills knowledge I acquired during the program. I was able to see the real picture of qualitative research, and challenges and problems of conducting qualitative study" [Bel G] "I would like to enhance my skills in conducting research and to be more involved in projects like this" [Laurente].	Improvement of research skills in general (f=15)	Research Skills improvement	
"I am looking forward to more productive research engagements with my learning institution to deliver quality research services to my future students" [Raqs G]. "The knowledge I gained during the mentoring process will be very helpful when I will be conducting my researchers. During the mentoring, I learned about the protocols in conducting interviews and classroom observations" (2) [Bel G]. "Honestly, my experiences were beyond words. On a personal note, it was indeed a meaningful and memorable academic learning endeavor" [Raqs G].	Learnings of participants (f=15)	Professional development and personal improvement	
"As a teacher, the experience and knowledge I gained from my involvement in this project and mentoring program will help me improve my teaching skills. As a research teacher, I could also see these to give more meaningful classroom discussions with my students." [Laurente]	Improvement of teaching of research skills (f=4)		
"Content upgrading is what we have drawn from the use of technology in research, and the learning derived from interacting with fellow STEAM educators." [Bel G].	Content upgrading (f=10)		

DISCUSSION

The study described a PAR-influenced mentoring program that highlights research cells as the unit skills improvement. Abstractions and thematization led to themes parallel to the aforementioned priori constructs.

Mentoring Program

In the mentoring program, Kegan's theory on the distinct stages of experiences (McGowan et al. 2007) was visible. The mentees in the early development stage might expect a mentor as a guiding authority, while more advanced mentee might prefer a

mentor who questions deep-seated beliefs and engage them in reflective and progressive development (Dominguez and Hager 2013). Apparently, the mentoring program had reached this state in the different levels of mentoring within the research cells. In fact, multiple and simultaneous mentoring methods (traditional mentoring, group mentoring, peer mentoring), exemplifying the importance of mentoring relationships (Kram 1985) and emerging varied bonds were vivid in each research cell. A system of transfer of technology and knowledge empowering the participants (Darwin 2015) through the participatory nature of the program that evolves developmental approach (Feldhaus and Bentrem 2015) and peer mentoring (Khoo et al. 2019) were evident. Raqs G, a senior mentee claimed, "I was happy to learn that I had mentees who successfully and actively participated in the field work". Everyone, from mentors to junior mentees, engages in the rigors of theory-practice-reflection (Morales 2019) in the different forms of mentoring imbedded in the program (e.g. a resource-based, group mentoring, training-based, and executive mentoring) (Reh 2019).

Collaborative Practice and Action

The participants encountered challenges and difficulties forcing them and the team to take action, which, then led to opportunities for collaborative practice for research implementation (Lodge et al. 2018). In fact, these encountered challenges and with the objective assessment of mentors, initiated practice and simulations within the research cells (either face-to-face or online) strengthened their bonds within their respective cells to practice collaboration and participatory contribution. AI by the mentors may have helped the participants transform these challenges to positive perspectives (Won and Choi 2017). An example, one of the mentors blatantly expressed, "I think you should practice more on conducting the interview" to his group while on board a field work. Evidently, collaborative learning and practice, which include celebrating, setting goals and reflecting on progress, peer teaching, critiquing and revising, and problem solving (Martin 2017) were manifested in each research cell and demonstrated the ideals of participatory framework that showcase reflective practices (Morales 2019). In fact a senior mentee [M Torre] claimed, "I feel proud that I was able to contribute to improving the research skills of the members of my cell and this also developed me as a researcher and mentor."

Benefits of Mentoring Program on Research Skills, and Reflective Practice

As teachers, all mentees were able to enhance their professional practice and research skills. They value the "technical improvement" and enhancement of their research skills by building their confidence in doing qualitative research and analysis (Kiersma et al. 2012). Their reflections implied that the program may have provided them the nexus for bridging theory and practice of research (Joubert and de Villiers 2015). They also considered "professional improvement" that highlighted their professional development through protege orientation. Evidently, there were good and strong mentor-mentee relationships that motivated mentees for productive research engagement. Holistically, the individual benefits that the participants derived from the project created their positive outlook towards research, notwithstanding the fact that their respective research cells instituted activities and relations that instigated skills improvement of both the mentors and the mentees. Overall, they attested that they were retooled and were able to sharpen their skills and felt that the mentoring program somehow impacted their character as teacher-researcher (Table 5).

Finally, the participants believed that they gained pedagogical knowledge improvement through country-wide exposure to the real conditions of research and education in STEAM programs.

These results imply that PAR as a methodical and program framework established a structured mentoring program beyond the scope of adviser-advisee mentoring, exemplifying collaborative learning, practice, and action. The program engaged all faculties—physical, emotional, socio-cultural, and psychological—of mentors and mentees leading to reflective and reflexive actions that might have developed a habit of mind and a reflective and reflexive culture. The activities within the mentoring program value the triangulation of theory-practice-reflection that helped the graduate students enhance their research skills and become good field researchers for the state-funded research.

The study is a documentation of a mentoring program of the state-funded research that reports a rich set of experiences of mentors and mentees. However, data collection may include video/audio recording of field observations for the mentoring process to capture all data sourced from the volunteers as mentees. PAR as a methodical and program framework may augment and complement professional learning and continuing professional development programs with an aspect of a micro-credentialing system in graduate school in-service field.

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Baseline study on the freshwater ornamental fish industry in Palawan, Philippines

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ABSTRACT

The status of both freshwater and marine ornamental fish industries in the Philippines has been assessed in 2019; however, Palawan was excluded due to the unavailability of data with regard to the ornamental fish trade. Hence, this study collected baseline data on the freshwater ornamental fish industry specifically the distribution of freshwater ornamental fish hobbyists, socio-demographic profile of the respondents, the key players involved in the market chain, classification and number of fish species and strains involved, and the challenges (economic and scientific) and opportunities encountered by the key players which could be used for the improvement and development of the ornamental fish sector in Palawan. A poll was conducted in order to obtain information on the general location of the ornamental fish hobbyists in Palawan in which 77 individuals participated. An online survey form was then sent to participants, however, only 40 responded. The freshwater ornamental fish hobbyists were distributed in 11 localities of Palawan. Key players involved in the market chain of freshwater ornamental fish were categorized as producers, traders, and sellers. Twelve freshwater ornamental fish species with 83 strains/varieties were involved, dominated by the Siamese fighting fish and guppy. Economic and research problems were some of the problems cited by the key players.

Keywords: challenges and opportunities, key players, market chain, online survey, strain

INTRODUCTION

Ornamental fish keeping was known as the second largest hobby in the world with millions of enthusiasts (Lipton 2006). It was a multi-billion-dollar aquaculture-based industry with an annual demand of USD 10 billion globally (Rao et al. 2013; Dey 2016; Ponraj 2019) which involved both freshwater and marine ornamental fish sectors (Livengood and Chapman 2007; Muyot et al. 2019). In the freshwater sector, more than 4,000 species were involved (Faruk et al. 2012) wherein the 90% traded worldwide were farm-produced (Faruk et al. 2012; Bassleer 2017) and 65% originated from developing countries in Asia (Livengood and Chapman 2007). Thailand, Malaysia, Singapore, Indonesia and Vietnam were the top five freshwater ornamental fish - producing countries (Mutia et al. 2007; Dey 2016).

The continued increasing production due to high demand globally and the potential to become one of the alternatives for aquaculture as source of income brought many problems to the freshwater ornamental fish industry (Rao et al. 2013; Dey 2016). A review paper of Biondo and Burki (2020) emphasized that data on ornamental fishes, both marine and freshwater, were still limited making the number and diversity of fishes in the trade unclear. There was also a growing concern about the impact and monitoring on the importation of ornamental fish as this could be the cause for the spread of diseases which can adversely affect the environment and biodiversity (Rose et al. 2013; Dey 2016). Even though the quantity of ornamental fish produced met the demand for trade, lack of knowledge and appropriate trainings on how to improve the growth, survival rate, forms and color of freshwater ornamental fish are still the biggest problems for its development (Maceda-Veiga et al. 2016; Muyot et al. 2019).

Although ornamental fishes were not among the priority species of the Philippine government, it was still part of the major exported fish species as of 2019 (BFAR 2019). Moreover, the recent published study of Muyot et al. (2019) reported that the Philippines produced 14,304,739 pieces of freshwater ornamental fish worth PHP 145,958,667 and has the potential to become a booming industry. On the other hand, Palawan is known as one of the major sources of marine ornamental fish in the country (Dalabajan 2005), but the province was not included in the latest studies dealing with ornamental fishes (Muyot et al.

2018, 2019). Moreover, published records on the potential of Palawan for freshwater ornamental fish were still non-existent. Further, Palawan was proclaimed as the last ecological frontier of the Philippines and was designated as a biosphere reserve by the UNESCO - Man and Biosphere Programme (MAB) in 1990 (Sandalo and Baltazar 1997). Therefore, this baseline study on freshwater ornamental fish in Palawan will give information on the distribution of freshwater ornamental fish hobbyists, socio-demographic profile of the respondents, the key players involved in the market chain, classification and number of fish species and strains involved, and the challenges (economic and scientific) and opportunities encountered by the key players in freshwater ornamental fish industry in Palawan that could be used as baseline data for future conservation, other research and economic studies related to freshwater ornamental fish.

METHODS

Study Site

The study covered the whole province of Palawan (9˚30'N and 118˚30'E) which has 23 municipalities and one city (Figure 1).

Data Collection

Due to the surge of COVID-19 cases starting 2020 and the restrictions that came with it, data on the distribution of freshwater ornamental fish hobbyists in Palawan were monitored through Facebook and the Messenger group of Palawan Fish Hobbyist which has more than 112 members engaged in freshwater ornamental fish activities in Palawan from March 2019 to May 2021. In order to obtain information on the general distribution of ornamental fish hobbyists throughout Palawan, a poll was conducted in the above-mentioned social media group. The poll was participated by 77 individuals where the online survey form was sent, however, only 40 responded. The respondents were then classified into various types of key players based on their level of engagement in the freshwater ornamental fish industry (Table 1). The survey form consists of multiple-choice questions on the demographic profile and other activities related to the freshwater ornamental fish in Palawan including the challenges and opportunities encountered by the key players. Informed consent was obtained from the respondents prior to the conduct of the survey on 27 March to 18 May 2021.

Data Analysis

All data collected were encoded and tallied in MS Excel for descriptive (frequency and percentage) and quantitative analysis. The data percentage were obtained by dividing each of the variables' value by 40 and then multiplying by 100. The tables present the distribution of these variables per key player so as to give ample baseline information on the status of the ornamental fish industry in Palawan.

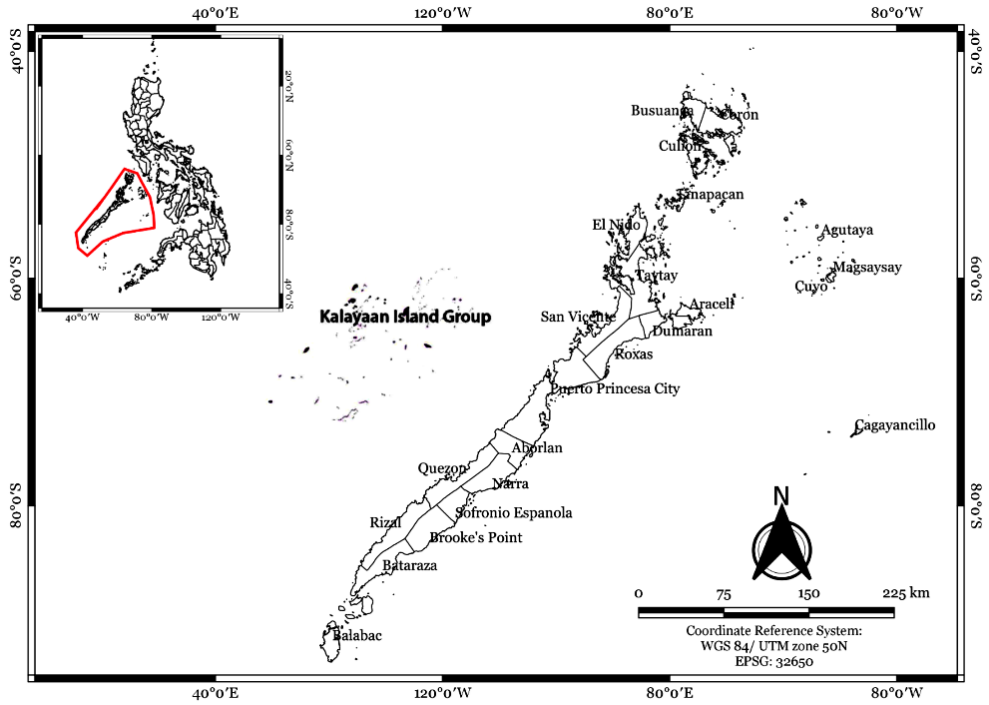

Figure 1. The map of Palawan and its 23 municipalities and one city as the target areas of the study.

Table 1. Classification and condition of key players in this study based on the surveyed respondents.

Classification	Conditions	Definition
Producers	Spend at least 80-90% of their time on breeding and farming activities	A person who keeps and produces fish in aquaria or ponds, multiplies fish in large quantities for profit and has some level of knowledge and expertise in genetics, breeding, and animal husbandry.
Traders	Spend at least 80-90% of their time on trading and dealing	Those who act as middlemen and usually buy fish of different species from producers on a wholesale basis and sell these fish to retailers or pet shops.
Sellers	Spend at least 80-90% of their time on selling	Those who sell freshwater ornamental fish directly to consumers on a retail basis.

RESULTS

Distribution of Freshwater Ornamental Fish Hobbyist in Palawan

The freshwater ornamental fish hobbyists in Palawan were distributed in 11 localities (Figure 2). Puerto Princesa City (61%) and Narra (12%) has the highest number of hobbyists, while Araceli has the lowest with only 1% (Figure 2).

Socio-demographic Profile of the Respondents and the Key Players Involved in Market Chain

The market chain of the freshwater ornamental fish in Palawan involves mainly three key players (Figure 3, Table 2). Out of the 40 respondents who participated in the online survey, 27 are producers, 12 are traders, and only one is a seller (Table 2). The majority of the respondents are male (75%), aged 16-20 years old (30%). More than half (65%) of the respondents were just starting to venture into the freshwater ornamental fish industry. Producers mostly bought freshwater ornamental fish to be used as breeders once or twice a month (47.5%); while traders (20%) and seller (2.5%) mostly bought freshwater ornamental fish on a daily basis. Ornamental fishes were sourced from within or outside Palawan. (Table 2).

Number of Species and Strains Involved in Freshwater Ornamental Fish Industry in Palawan

There were 12 species of freshwater ornamental fish involved in the ornamental fish industry in Palawan with 83 strains/varieties (Table 3). Betta (20) and guppy (16) were the most common freshwater ornamental fishes in Palawan as indicated by the number of strains available for these fishes. Most of the strains were locally-produced by the producers (Table 3).

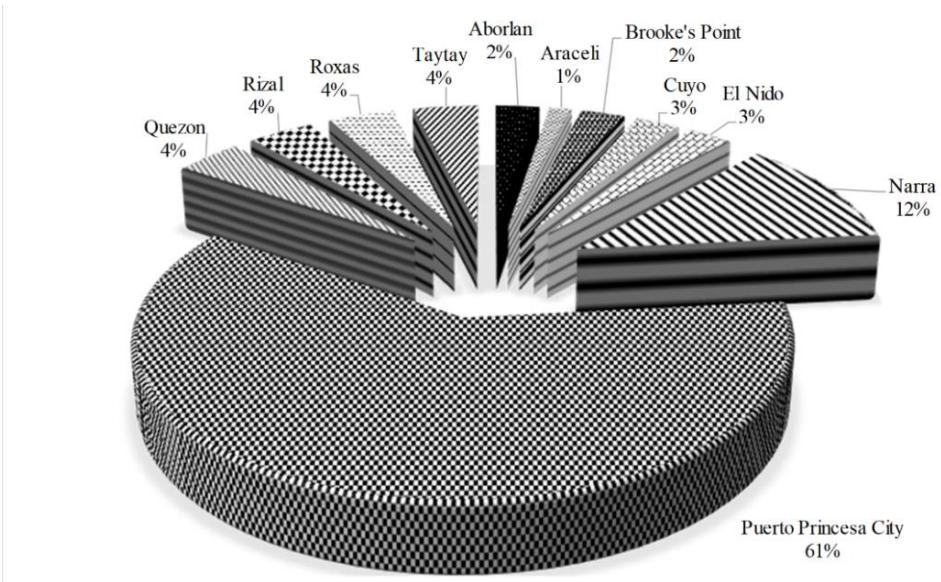

Figure 2. Percent distribution of freshwater ornamental fish hobbyists and number of localities with fish hobbyist in Palawan based on the online poll conducted (n=40).

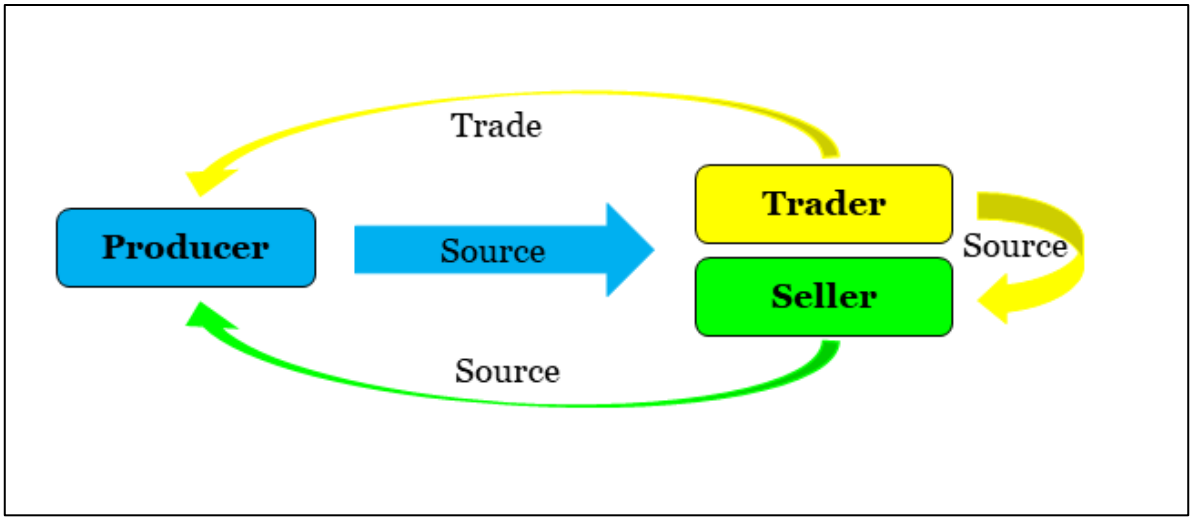

Figure 3. The key players involved in the market chain of freshwater ornamental fish industry in Palawan.

Table 2. Socio-demographic profile and other additional information on the market and activity of the respondents who participated in the online survey. (n=40, the data are presented in frequency and percentage (%). *multiple answers per respondent. Producer (n=27); Traiders (n=12) and Seller (n=1).

Variable	Producers (%)	Traders (%)	Sellers (%)	Total (%)
Sex				
Male	20 (50)	9 (22.5)	1 (2.5)	30 (75)
Female	4 (10)	1 (2.5)	0	5 (12.5)
Others	3 (7.5)	2 (5)	0	5 (12.5)
Age (yrs. old)				
13-15	1 (2.5)	0	0	1 (2.5)
16-20	7 (17.5)	5 (12.5)	0	12 (30)
21-25	4 (10)	3 (7.5)	0	7 (17.5)
26-30	7 (17.5)	1 (2.5)	0	8 (20)
31-35	5 (12.5)	1 (2.5)	0	6 (15)
36-40	2 (5)	2 (5)	1 (2.5)	5 (12.5)
> 41	1 (2.5)	0	0	1 (2.5)
Years in freshwater ornamental fish industry				
1	18 (45)	8 (20)	0	26 (65)
2-5 years	7 (17.5)	2 (5)	0	9 (22.5)
> 6	2 (5)	2 (5)	1 (2.5)	5 (12.5)
Frequency of buying ornamental fish				
Daily	2 (5)	8 (20)	1 (2.5)	11 (27.5)
Once a week	3 (7.5)	3 (7.5)	0	6 (15)
Once or twice a month	19 (47.5)	0	0	19 (47.5)
Once or twice a year	4 (10)	0	0	4 (10)
Amount of money spent				
Below 500	10 (25)	8 (20)	0	18 (45)
600-1000	9 (22.5)	1 (2.5)	0	10 (25)
> 1000	8 (20)	3 (7.5)	1 (2.5)	12 (30)
Source of ornamental fish*				
Local market	27 (67.5)	12 (30)	1(2.5)	40 (100)
Other parts of the Philippines	27 (67.5)	12 (30)	1 (2.5)	40 (100)
International market	7 (17.5)	4 (4)	0	11 (27.5)
Number of species of ornamental fish in possession				
1-2	5 (12.5)	2 (5)	0	7 (17.5)
3-5	12 (30)	4 (4)	0	16 (40)
> 6	10 (25)	6 (15)	1 (2.5)	17 (42.5)

Table 3. Species and strains of freshwater ornamental fish present in Palawan. (n=40, the data is presented in frequency and percentage (%)). *multiple answers per respondent.

Species	Strain/ Variety*	Producers (%)	Traders (%)	Sellers (%)	Number of Strain/ Variety
Angelfish (*Pterophyllum scalare)*	Albino	1 (2.5)	1 (2.5)	0	6
	Golden head	1 (2.5)	1 (2.5)	0	
	Marble	4 (10)	2 (5)	0	
	Philippine blue	4 (10)	1 (2.5)	1 (2.5)	
	Sta. Isabel	1 (2.5)	0	0	
	Zebra	3 (7.5)	1 (2.5)	1 (2.5)	
Arowana (*Scleropages* sp.)	Silver	1 (2.5)	3 (7.5)	1 (2.5)	1
Cardinal tetra (*Paracheroidon axelrodi*)	Black skirt	0	1 (2.5)	0	5
	Buenos aires	1 (2.5)	0	1 (2.5)	
	Neon	4 (10)	2 (5)	1 (2.5)	
	Tiger	1 (2.5)	1 (2.5)	0	
	White skirt	1 (2.5)	1 (2.5)	0	
Flowerhorn (*Vieja synspilum*)	Golden base	1 (2.5)	1 (2.5)	0	4
	Kamfa	9 (22.5)	1 (2.5)	1 (2.5)	
	Nakeemix	1 (2.5)	2 (5)	0	
	Zhen zhu	9 (22.5)	2 (5)	0	
Siamese fighting fish (*Betta splendens*)	Alien hybrid	1 (2.5)	0	0	20
	Crowntail (bicolor)	1 (2.5)	1 (2.5)	1 (2.5)	
	Crowntail (patterned and multicolor)	1 (2.5)	2 (5)	1 (2.5)	
	Crowntail (solid)	3 (7.5)	2 (5)	1 (2.5)	
	Delta (bicolor)	1 (2.5)	1 (2.5)	1 (2.5)	
	Double tail (bicolor)	1 (2.5)	2 (5)	1 (2.5)	
	Double tail (patterned and multicolor)	1 (2.5)	0	0	
	Double tail (solid)	0	1 (2.5)	0	
	Dumbo ear	2 (5)	0	0	
	Halfmoon (bicolor)	5 (12.5)	2 (5)	1 (2.5)	
	Halfmoon (patterned and multicolor)	3 (7.5)	2 (5)	1 (2.5)	
	Halfmoon (solid)	14 (35)	1 (2.5)	1 (2.5)	
	Halfmoon plakat (bicolor)	3 (7.5)	1 (2.5)	1 (2.5)	
	Halfmoon plakat (patterned and multicolor)	4 (10)	1 (2.5)	0	
	Halfmoon plakat HMPK (solid)	17 (42.5)	5 (12.5)	1 (2.5)	
	Own breed	5 (12.5)	0	0	
	Rosetail (bicolor)	1 (2.5)	0	0	
	Rosetail (solid)	1 (2.5)	0	0	
	Vailtail (multicolor)	1 (2.5)	0	0	
	Wild	1 (2.5)	1 (2.5)	0	
Goldfish (*Carassius auratus*)	Black moor	1 (2.5)	1 (2.5)	0	7
	Bubble eye	1 (2.5)	0	1 (2.5)	
	Oranda	4(10)	1 (2.5)	1 (2.5)	
	Ranchu	4 (10)	1 (2.5)	1 (2.5)	
	Ryukin	6 (15)	1 (2.5)	0	
	Shubunkin	7 (17.5)	0	0	
	Telescope	4 (10)	0	0	
Guppy (*Poecilla reticulata*)	Albino blue topaz	4 (10)	2 (5)	0	16
	Albino full red	4 (10)	2 (5)	1 (2.5)	
	Black lace	8 (20)	5 (12.5)	0	
	Black Moscow	3 (7.5)	0	0	
	Blue grass	3 (7.5)	1 (2.5)	0	
	Chops	11 (27.5)	6 (15)	1 (2.5)	
	Dumbo ear mosaic	1 (2.5)	0	0	
	Dumbo firetail	8 (20)	4 (10)	0	
	Electric blue Moscow	10 (25)	4 (10)	0	
	HB blue	2 (5)	0	0	

Species	Strain/ Variety*	Producers (%)	Traders (%)	Sellers (%)	Number of Strain/ Variety
	HB red	6 (15)	(2.5)	0	
	HB white	2 (5)	1 (2.5)	0	
	Own breed	1 (2.5)	1 (2.5)	0	
	Purple dragon	1 (2.5)	0	0	
	Red lace snakeskin	15 (37.5)	1 (2.5)	0	
	Yellow king cobra	3 (7.5)	0	0	
Japanese koi (*Cyprinus carpio*)	Kohaku	5 (12.5)	1 (2.5)	1 (2.5)	2
	Sanke	4 (10)	0	0	
Molly (*Poecilla sphenops*)	Balloon belly molly	12 (30)	1 (2.5)	0	7
	Black molly	9 (22.5)	3 (7.5)	1 (2.5)	
	Dalmatian molly	6 (15)	3 (7.5)	0	
	Gold dust molly	10 (25)	1 (2.5)	0	
	Marble molly	5 (12.5)	3 (7.5)	0	
	Platinum molly	5 (12.5)	0	0	
	Yamabuki red eye	1 (2.5)	0	0	
Platy (*Xiphophorus maculatus*)	Gold	2 (5)	0	0	3
	Panda	2 (5)	4 (10)	0	
	Red	1 (2.5)	0	0	
Swordtail (*Xiphophorus helleri*)	Albino	2 (5)	0	0	6
	Black	4 (10)	0	0	
	Kohaku	13 (32.5)	3 (7.5)	0	
	Koi swordtail	1 (2.5)	0	0	
	Sanke	9 (22.5)	2 (5)	0	
	Velvet	1 (2.5)	0	0	
Zebrafish (*Danio rerio*)	Green danio	1 (2.5)	0	0	6
	Pearl danio	1 (2.5)	0	0	
	Pink danio	1 (2.5)	0	0	
	Rosy danio	1 (2.5)	0	0	
	Yellow danio	1 (2.5)	0	0	
	Zebra danio	5 (12.5)	0	0	

Challenges and Opportunities in Freshwater Ornamental Fish in Palawan

Challenges and opportunities encountered by the key players in freshwater ornamental fish keeping were listed in Table 4. The challenges were classified into economic and scientific problems. Interestingly, some of the challenges listed by the respondents became opportunities to improve and sustain the production of freshwater ornamental fish in Palawan (Table 4).

Table 4. Challenges (economic and scientific) and opportunities encountered by key players in the freshwater ornamental fish industry in Palawan (n=40), results are presented in (F) frequency and percentage (%).

Key Players	Challenges				Opportunities
	Economic	F (%)	Scientific	F (%)	
Producer (n=27)	Limited capital	27 (100)	Inadequate knowledge in breeding	22 (81.48)	1. Reduce the number of freshwater ornamental fish species being cultured
	Limited participants on fish shows	15 (55)	Low-quality breeding materials	27 (100)	2. Knowledge-sharing among hobbyists regarding the best practices in breeding and propagation.
	Expensive feeds	27 (100)	Limited strains of fish in Palawan	27 (100)	3. Able to identify ornamental fish farms in Palawan that can supply quality breeders
	Problems in organizing on-site (bench-in) shows	10 (37)	Limited source of natural food	10 (37)	4. Exchange of male or female broodstock among breeders to improve the quality and quantity

Key Players	Challenges				Opportunities
	Economic	**F (%)**	**Scientific**	**F (%)**	
					of freshwater ornamental fish production
	Limited experts who can be invited as judges to the fish show	10 (37)	Difficulty in improving the quality of fish	15 (55)	5. Some of the breeders maintain and sell starters for natural food production (e.g. *Daphnia, Tubifex*, etc)
			Insufficient supply of culture materials such as aquaria, cleaning materials etc.	19 (70.37)	6. Use of mixed feeding using natural food and formulated diets
			Diseases causing high mortality in fish	27 (100)	7. Use of Indian almond tree (Talisay) leaves to enhance the color and vigor and to reduce risk of infections and disease occurrence in fish
					8. Feed the fish with color-enhancing feeds
					9. Recycling of plastic polyethylene terephthalate (PET) bottles and learning how to cut glass bottles to be used in the breeding farms
					10. Produce new and unique strains of freshwater ornamental fish
					11. Stress reliever/ therapy
					12. Frequent fish shows to promote freshwater ornamental fish in Palawan
					13. Online and on-site shows are now possible
					14. New acquaintances from all around Palawan
Trader (n=12)	Unstable price of freshwater ornamental fish produced locally	12 (100)	Occurrence and recurrence of diseases	12 (100)	1. Buy only from trusted breeders to ensure the quality of the fish.
	Very high price of freshwater ornamental fish	10 (83.33)			2. Wise scheduling of shipping to avoid loss of money and fish.
	Limited courier services	7 (58.33)			3. Buy directly from the local suppliers.
	Inability to compete with other known traders in Palawan	10 (83.33)			
	Inadequate supply and low quality of locally-produced freshwater ornamental fish	12 (100)			4. Opportunity for online trading
Seller (n=1)	Unstable price of freshwater ornamental fish produced locally	1 (100)	Occurrence and recurrence of diseases	1 (100)	1. Buy only from trusted breeder or trader to ensure the quality of the fish.
	Limited courier services	1 (100)			2. Wise scheduling of shipping to avoid loss of money and fish.
	Inability to compete with other known sellers in Palawan	1 (100)			3. Buy directly from local suppliers.

Key Players	Challenges				Opportunities
	Economic	F (%)	Scientific	F (%)	
	Inadequate supply and low quality of locally-produced freshwater ornamental fish	1 (100)			4. Opportunity for online selling

DISCUSSION

Distribution of Freshwater Ornamental Fish Hobbyist in Palawan

The distribution of freshwater ornamental fish hobbyists in 11 localities is an evidence that a robust freshwater ornamental fish industry is present in Palawan. The reasons for the increasing number of fish hobbyists in freshwater ornamental fish keeping and breeding in Palawan is due to its health and financial benefits especially during the surge of COVID-19. Clements et al. (2019) emphasized that interaction with fishes in the aquarium could reduce anxiety, physiological stress, loneliness, nutritional intake and body mass, and glycemic control, while Duco and Vallejo (2003); Ghosh et al. (2003); Laskar et al. (2016) mentioned that ornamental fish keeping could be a source of alternative income from selling own-bred fishes. Aside from being the capital of Palawan, the high number of freshwater ornamental fish hobbyists in Puerto Princesa City could be due to its accessibility and the availability of fish keeping supplies.

Socio-demographic Profile of the Respondents and the Key Players Involved in the Market Chain

Male (75%) aged 16-20 (30%) are the most active fish hobbyists in Palawan (Table 2) which is comparable to the study of Laskar et al. (2016) in India. The nature of ornamental fish keeping required labor and time especially when it comes to aquarium setting, water change and aquarium maintenance (Yadav and Sharma 2017). Since most of the water source in Palawan are chlorinated tap water, most of the hobbyists stock the water to eliminate the chlorine before using it, while others need to fetch from a water well/pump to ensure the safety of the fishes. Chlorine was known to have severe side effects on ornamental fish (Tullock 2006; Illes 2007). This explains why there are more male aged 16-30 than older male, and significantly less female actively engaged in the ornamental fish industry. Due to its time-consuming and labor-intensive nature, female are less engaged in ornamental fish keeping as most of their time were spent in households or in the other sources of income (Yadav and Sharma 2017).

The market chain of freshwater ornamental fish in Palawan is quite complicated as the three key players involved were also the end users of the ornamental fishes produced or for sale in the local market in Palawan. For instance, there are cases when the producer purchased fish from trader or seller. This happens when the breeder wants to breed certain strains of fish that are not available in the local farm. This explains why most (75%) of the producer's fish supply were from local sources (Table 2). On the other hand, traders' supply of fish (72.73%) are mainly from other parts of the country (Table 2), although sometimes they buy fish from sellers to sell to producer, especially when the freshwater ornamental fish available in the seller's store are rare. Also, seller tend to purchase fish directly from the producer instead from the trader to maximize profit. Compared to Tripura in India, the market channels of ornamental fish involved the seven major players in which the traders mostly purchased fish outside Tripura due to the low quality of fish produced by local producers (Yadav and Sharma 2017). The duration of involvement and number of respondents in each key player in ornamental fish keeping could be the reason why the market chain in Palawan revolved mainly within local production as most (50%) of the respondents have just started venturing into ornamental fish keeping (Table 2). Although this study did not include the value chain analysis for each species per classification due to variation of value, an estimated 50% price increase was observed from producer to trader and another 50% from trader to seller. The price of freshwater ornamental fish also varied depending on the rarity of the species, purity of the line, and the costs required to produce certain species of fish such as feed, manpower, utility, and many others.

Number of Species and Strains Involved in Freshwater Ornamental Fish Industry in Palawan

The 12 species of freshwater ornamental fish and 83 strains/varieties involved in the freshwater ornamental fish industry in Palawan is much lower compared to the 94 species and 422 varieties in the Philippines (Muyot et al. 2019). All of these freshwater ornamental fish species are exotic, introduced and mainly captive-bred (Muyot et al. 2019). Since the freshwater ornamental fish was just

starting to gain popularity among Palaweños, this could be the reason for the low number of species involved.

The Siamese fighting fish (Betta) and guppy are the most common freshwater ornamental fish species in Palawan. Although they are more difficult to breed due to a large number of strains, color, and pattern combinations (Tullock 2006), they were the most popularly traded species in Palawan. Betta and guppy are sold based on its quality or classification because they are entered in fish beauty competitions locally and abroad (Table 3). Although Betta and guppy fish are not endemic to the Philippines, there is a potential that the Philippines can also produce its own type in the near future through selective breeding (Figure 4). Like Thailand, they were able to produce a betta fish that represent the colors of their national flag (blue, red, and white) and considered as the most expensive and high-quality betta in the world (Sermwatanakul 2019).

Challenges and Opportunities in Freshwater Ornamental Fish in Palawan

The culture system, facilities, breeding program and biosecurity were just some of the factors that contribute to the sustainability of production in ornamental fish industry (Livengood and Chapman 2007; Muyot et al. 2019). The existing culture system in Palawan is the open system wherein the rearing facility is subject to the changes in the weather condition, temperature, amount of daylight, and the availability of water. Very few invest in a closed system such as the recirculating system. The main reason for this is the inappropriate design of their farm and the additional cost that would be incurred in establishing a recirculating system. Producers in Palawan usually use small aquaria, PET bottles, small modified outdoor ponds, ref tubs and basins to raise their fish. The use of recyclable materials in the production of ornamental fish partly contributes to the environmental waste reduction. Few producers use selective and line breeding methods in the production of freshwater ornamental fish. Selective and line breeding are important techniques that allow producers to develop new or improve existing strains, increase fish production and potentially bring more profit (Singh el al. 2010). Producers sometimes import breeders to breed high quality lines of freshwater ornamental fish. In addition, some producers participate in fish shows and use the imported fish as entries. The occurrence and recurrence of diseases in the producers' farms was also observed in this study, indicating that biosecurity is poorly applied in the production farms. This made the farms vulnerable and highly-susceptible to diseases (Walczak et al. 2017; Preena et al. 2019).

Data on the import and export value of freshwater ornamental fish in Palawan are not available. However, based on local observation and interviews from other fish hobbyists, most traders and sellers import freshwater ornamental fish which is depriving local producers the opportunity to earn money. According to traders and sellers, there is a shortage of freshwater ornamental fish in Palawan. In addition, most locally-produced fishes are of poor quality making them difficult to sell.

Figure 4. Example of locally-bred strain of Siamese fighting fish (A) and guppy (B) from a breeder farm in Palawan.

The freshwater ornamental fish industry has tremendous potentials in Palawan in terms of helping the economy and bringing prestige to the Philippines as one of the major producers of these kinds of commodity. Bartley (1999) emphasized that those involved in the fish trade should have a shared responsibility to ensure that the industry is environmentally sustainable. Therefore, in order to sustain the production of freshwater ornamental fish in Palawan, producers need to upgrade their knowledge in breeding, genetics, and animal husbandry and at the same time invest in improving their facilities. Traders and sellers on the other hand need to patronize locally-produced fish and promote its market outside Palawan. Government support to strengthen and sustain the production through research and extension services offered by the academe, and trainings on marketing and value chain of the ornamental fish could benefit those involved in the freshwater ornamental fish industry.

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Some biological aspects of bogue *Boops boops* (Linnaeus, 1758) from Saros Bay (Northern Aegean Sea, Turkey)

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ABSTRACT

This study was conducted to determine the growth parameters, mortality and length at first maturity of bogue *Boops boops* (Linneaus, 1758) in Saros Bay (Northern Aegean Sea). A total of 363 specimens were obtained, monthly, from commercial fishermen between February 2016 and January 2017. The total length and weight of sampled fish ranged from 11.3 to 24.1 cm and from 16.61 to 165.32 g, with a mean of 16.9 cm and 60.40 g, respectively. The length-weight relationship was calculated as $W = 0.0080TL^{3.13}$. The von Bertalanffy growth equations were computed to be $L_\infty = 27.9$ cm, $k = 0.21$ year^{-1}, $t_0 = -1.57$ year. The growth performance index (Φ') was found as 2.21. The length at first maturity was estimated as 16.6 cm. Total mortality rate (Z), natural mortality rate (M), fishing mortality rate (F) and exploitation rate (E) of the bouge were 0.44 year^{-1}, 0.38 year^{-1}, 0.06 year^{-1} and 0.13 year^{-1}, respectively. The present study provides preliminary information on the growth parameters, mortality and length at first maturity of *B. boops* for the Saros Bay (Northern Aegean Sea, Turkey).

Keywords: fisheries management, growth parameters, Perciformes, Sparidae, stock assesment.

INTRODUCTION

The information on the age and growth of fish species is important for a comprehensive understanding of their population dynamics. This knowledge forms the basis for the calculations of growth, productivity estimates, and mortality rates (Campana 2001). In this connection, the growth parameters, the core of fisheries biology and ecology, are used for tasks such as: (a) development of stock assessment models (Hilborn and Walters 1992); (b) building of ecosystem models (Pauly et al. 2000); (c) testing life history patterns and tradeoffs, both within and between species (Rochet 2000; Stergiou 2000); (d) calculating maximum sustainable yield (Beddington and Kirkwood 2005); (e) estimating vulnerability of fish to overfishing (Cheung et al. 2005); and (f) predicting empirical equations for predicting other biological parameters, such as natural mortality (Pauly 1980) and length at first maturity (Froese and Binohlan 2000). The existence of accurate growth parameters estimates is essential for all of the above to be realized (Apostolidis and Stergiou 2014).

The Sparidae is a family of the order Perciformes and contains 164 species in 38 genera (Eschmeyer's Catalog of Fishes 2020). Recently, the family Centracanthidae (picarels) has also been merged with the Sparidae (Santini et al. 2014) while they previously were listed as distinct and separate (Golani et al. 2006; Nelson 2006; Mater et al. 2011). As far as it is known, 24 Sparidae species within 13 genera (*Boops* Cuvier, 1814; *Centracanthus* Rafinesque, 1810; *Dentex* Cuvier, 1814; *Diplodus* Rafinesque, 1810; *Evynnis* Jordan and Thompson, 1912; *Lithognathus* Swainson, 1839; *Oblada* Cuvier, 1829; *Pagellus* Valenciennes, 1830; *Pagrus* Cuvier, 1816; *Sarpa* Bonaparte, 1831; *Sparus* Linnaeus, 1758; *Spicara* Rafinesque, 1810; *Spondyliosoma* Cantor, 1849) from Turkish territorial waters were reported (Mater et al. 2011) and there are two more species (*Crenidens crenidens* Forsskål, 1775 and *Rhabdosargus haffara* Forsskål, 1775) in the Eastern Mediterranean (Golani et al. 2006) which are lessepsian (Paruğ and Cengiz 2020a).

The genus *Boops* is represented by two species, worldwide: *Boops boops* (Linnaeus, 1758) and *Boops lineatus* (Boulenger, 1892) (Froese and Pauly 2021). *Boops boops* is a demersal or semipelagic species inhabiting inshore waters above various bottoms (sand, mud, rocks or posidonia beds) in the whole Mediterranean, eastern and western Atlantic (Bauchot and Hureau 1986) and moves in aggregations, ascending to the surface mainly at night (Bauchot 1987). It is known to be distributed in all Turkish seas (Fricke et al. 2007). *Boops boops* is exported to European countries such as Greece and Italy, especially during the winter months in their fishing season which is found to be the most abundant. It is of economic importance, and fishing, widely used in the Northern Aegean Sea (Turkey), is commonly made with handline fishing, gill net, and purse seine (Cengiz et al. 2013). According to the Turkish Statistical Institute, *B. boops* yield from fisheries was 2598.8 tonnes (t) in 2020. In the whole General

Fisheries Commission for the Mediterranean (GFCM) areas, its landings varied from catch of 20.586 t in 2016 to 19.711 t in 2018 (FAO 2020).

There are many studies on biology of bogue (Girardin 1981; Anato and Ktari 1986; Girardin and Quignard 1986; Alegría-Hernández 1989; Djabali et al. 1990; Hassan 1990; Abdel-Rahman 2003; Allam 2003; El-Haweet et al. 2005; Khemiri et al. 2005; El-Okda 2008; Amira et al. 2019; Azab et al. 2019), as a summary. As for Turkish sea, the information on biology of *B. boops* come from Saros Bay (Cengiz et al. 2019), Edremit Bay (Bilge 2008), Izmir Bay (Öztürk 1998; Bilge 2008; Kara and Bayhan 2015; Soykan et al. 2015) and Babadıllimanı Bight (Manaşırlı et al. 2006). However, Ceyhan et al. (2018) and Cengiz (2021a) made studies on the maximum length records of the species, while Cengiz et al. (2013) and İlkyaz et al. (2017) extrapolated the selectivity parameters of bogue. This study provides preliminary information on the growth parameters, mortality and length at first maturity of *B. boops* for the Saros Bay (Northern Aegean Sea, Turkey) and compares these results with the previous studies in different areas of Mediterranean Basin.

METHODS

The northern Aegean coasts of Turkey are divided to sub-regions as the Saros Bay, the Gallipoli Peninsula, the Gökceada and Bozcaada Islands and the Edremit Bay (Cengiz and Paruğ 2020; Cengiz 2021b). The length of Saros Bay is about 61 km and the width at the opening to the Aegean Sea is about 36 km (Eronat and Sayın 2014). As the bay had been closed to bottom trawl fishing since 2000 (Cengiz et al. 2014) and no industrial activity was prevalent in the area (Sarı and Çağatay 2001), it can be considered as a pristine environment (Cengiz et al. 2015; Cengiz 2021c). For these reasons, Saros Bay and its coastal area were declared as a Special Environmental Protection Area (SEPA) due to its landscape, geomorphological, ecological, floristic biogenetic and touristic properties (Güçlüsoy 2015) (Figure 1).

Samples were obtained monthly between February 2016 and January 2017 in random stratified sampling from commercial fishermen catching fish species by drive-in fishing method around Saros Bay. The individuals were measured to the nearest centimeter (total length), weighed to the nearest 0.01 g (total weight). The length-weight relationship was estimated by fitting an exponential curve, $W = aL^b$ (Le Cren 1951). Parameters *a* and *b* of the exponential curve were estimated by linear regression analysis over log-transformed data $\log W = \log a + b\log L$, where W is the total weight (g), L is the total length (cm), *a* is the intercept, and *b* is the slope or allometric coefficient, using the least-squares method. Value $b > 3$ shows positive allometric growth, while value $b < 3$ indicates negative allometric growth. It is isometric growth when value *b* is equal to 3 (Bagenal and Tesch 1978). The growth type was identified by Student's *t*-test.

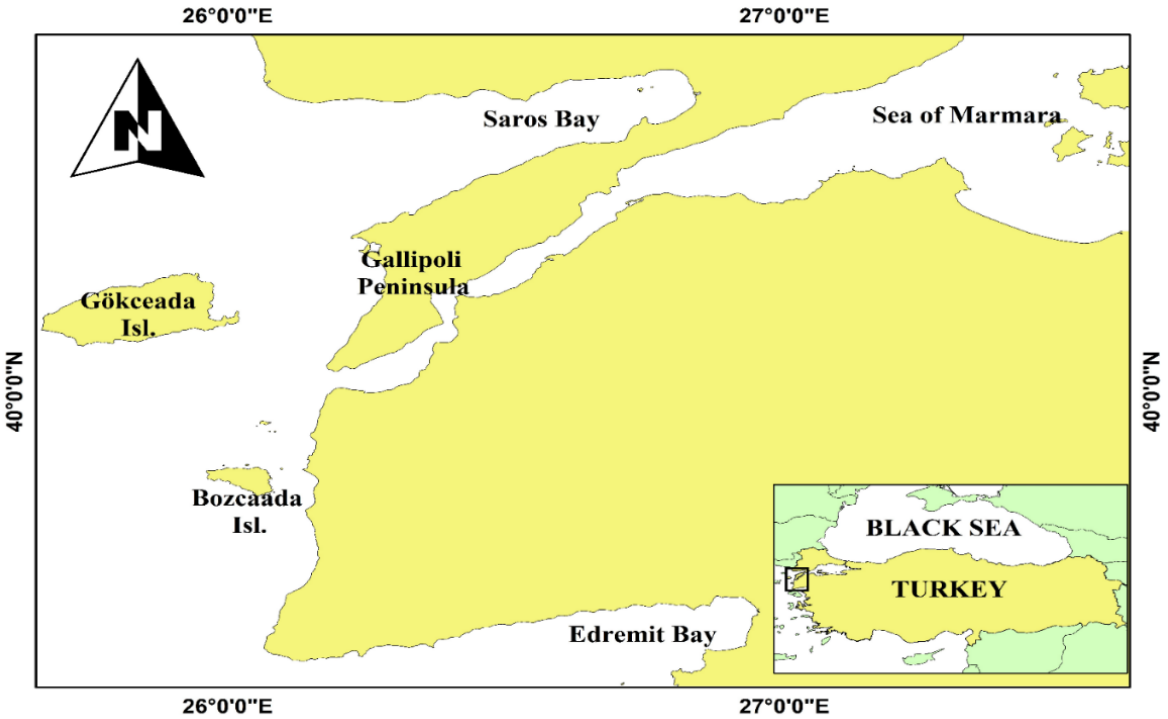

Figure 1. Saros Bay and the northern Aegean coasts of Turkey.

The otoliths were evaluated for age determination. Following removal, the sagittal otoliths were put in a mixture of first 5% HCL and then 3% NaOH solutions, washed in distilled water and subsequently dried. The sagittal otoliths placed in watch glass filled with water were read using a stereoscopic zoom microscope under reflected light against a black background. Opaque and transparent zones were counted; one opaque zone plus one transparent zone was assumed to be one year (Cengiz 2019). Growth parameters were estimated by using the von Bertalanffy growth equation: $L_t = L_\infty\ [1 - e^{-k\,(t - to)}]$, where L_t is fish length (cm) at age t, L_∞ is the asymptotic fish length (cm), t is the fish age (years), t_0 (years) is the hypothetical time at which the fish length is zero, and k is the growth coefficient (year^{-1}). FAO-ICLARM Stok Assessment Tools FISAT II) were used to estimate growth parameters, which were calculated with the non-linear least-squares method. The growth parameters obtained in this study were compared with the parameters obtained in other studies from various geographical areas using the growth performance index (Φ') (Pauly and Munro 1984). It was estimated using the formula, $\Phi' = \log(k) + 2*\log(L_\infty)$. The length at first maturity was determined from asymptotic length by using the empirical relationship of Froese and Binohlan (2000): $\log L_m = 0{\cdot}8979*\log L_\infty - 0.0782$ (for all samples). Total mortality rate (Z) was estimated from linearized catch curve based on age composition data (Sparre and Venema 1992). Natural mortality rate (M) was computed from Pauly (1980)'s multiple regression formula: M = 0.8*exp (–0.0152– 0.279*lnL∞ + 0.6543*ln K + 0.463*lnT), where L_∞ and K are the parameters obtained from the von Bertalanffy growth equation and T (°C) is the annual mean water temperature at the study locality. Fishing mortality rate (F) was estimated from F=Z–M, and the exploitation rate (E) from E=F/Z.

RESULTS

A total of 363 individuals were, monthly, collected from commercial fishmongers around Saros Bay. The mean ± standard error (and range) of total length and total weight for all samples were 16.9 ± 0.16 (11.3 – 24.1) cm (Figure 2) and 60.40 ± 1.79 (14.61 – 165.32) g, respectively. The length-weight relationship was estimated as $W = 0.0080TL^{3.13}$ (R^2 = 0.98) (Figure 3). The b-values and t-test results indicated positive allometric growth.

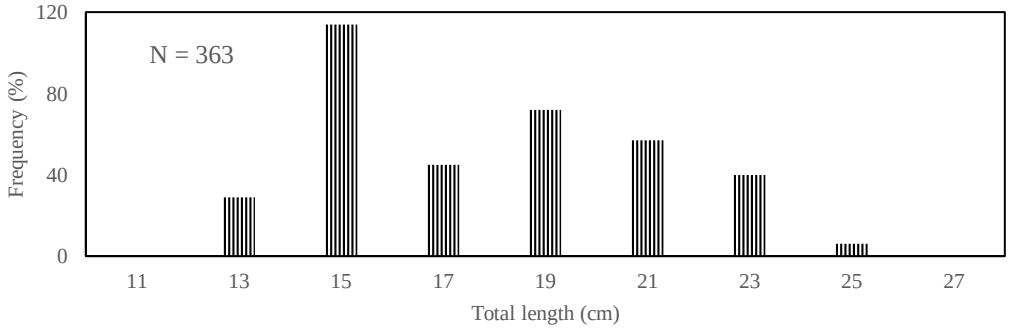

Figure 2. The length-frequency distribution for all samples of *Boops boops* from Saros Bay (Northern Aegean Sea, Turkey).

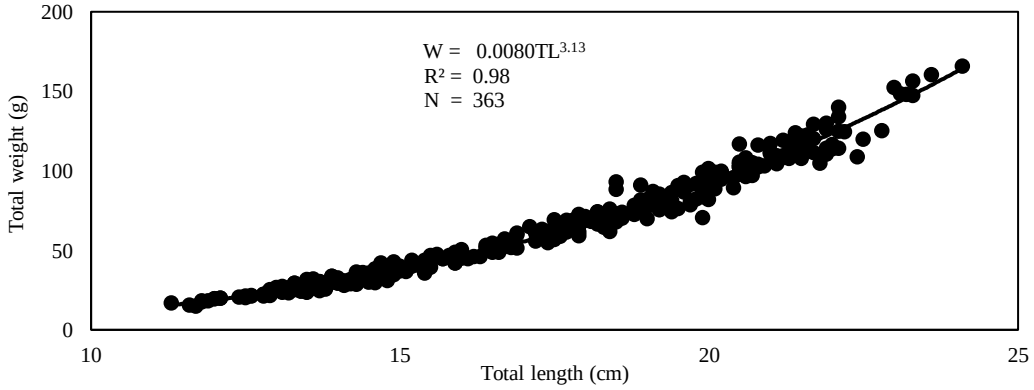

Figure 3. The length-weight relationships for all samples of *Boops boops* from Saros Bay (Northern Aegean Sea, Turkey).

Results obtained from the otolith reading of 363 individuals displayed that the ages of the fishes were found to be within the range of 1 to 9 years. Table 1 revealed fishes belonging to age groups 2 and 3 were the most dominant. The von Bertalanffy growth equations were computed as L_∞ = 27.9 cm, k = 0.21 year^{-1}, t_0 = –1.57 year for all samples (Figure 4). The growth performance index (Φ') was found as 2.21. The length at first maturity was estimated as 16.6 cm.

Total mortality rate (Z) for all samples was 0.44 year^{-1} (Figure 5). The annual water temperature mean in the study locality was 14.3°C. Thus, natural mortality rate (M) was estimated as 0.38 year^{-1}. Fishing mortality rate (F) was found to be 0.06 year^{-1}. The exploitation rate (E) was calculated as 0.13 year^{-1}.

Table 1. The age-length key for all samples of *Boops boops* from Saros Bay (Northern Aegean Sea, Turkey).

Length class (cm)	**Age (years)**									**All samples**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	
11.0 – 13.0	26	3	-	-	-	-	-	-	-	29
13.1 – 15.0	28	84	2	-	-	-	-	-	-	114
15.1 – 17.0	-	18	27	-	-	-	-	-	-	45
17.1 – 19.0	-	1	38	33	-	-	-	-	-	72
19.1 – 21.0	-	-	-	8	42	7	-	-	-	57
21.1 – 23.0	-	-	-	-	1	20	12	5	2	40
23.1 – 25.0	-	-	-	-	-	-	-	4	2	6
All samples										
N	54	106	67	41	43	27	12	9	4	363
%	14.88	29.20	18.46	11.29	11.85	7.44	3.31	2.48	1.10	100
Min	11.3	13.0	14.7	17.5	19.2	20.4	21.3	21.5	22.5	11.3
Max	13.9	17.4	19.0	20.2	21.5	21.9	22.2	23.3	24.1	24.1
Mean	13.0	14.4	17.0	18.6	20.0	21.3	21.9	22.6	23.3	16.9
S.E.	0.09	0.09	0.11	0.10	0.09	0.08	0.08	0.22	0.35	0.16

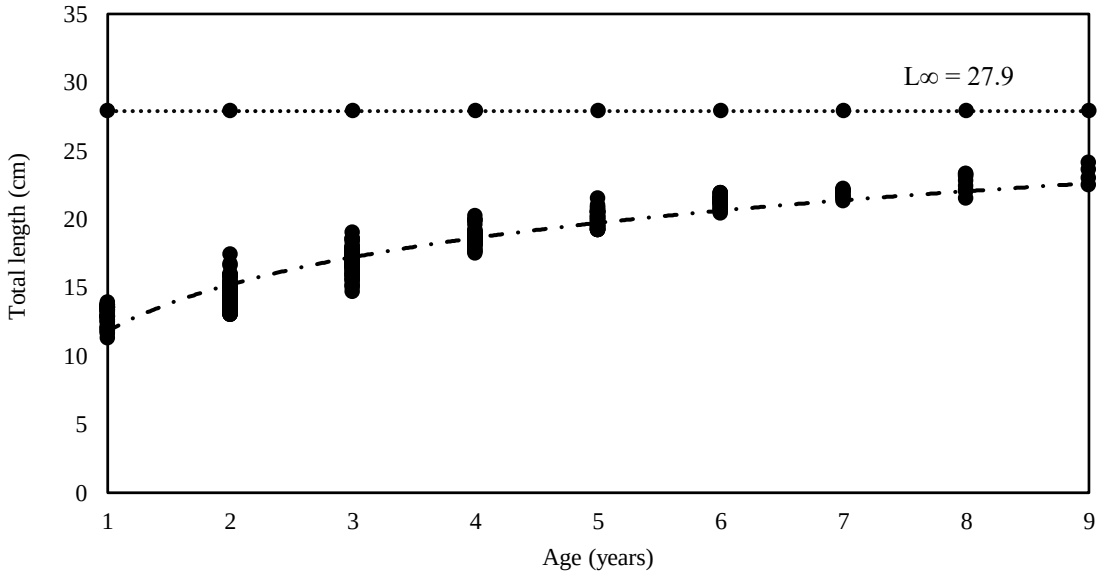

Figure 4. The growth curves for all samples of *Boops boops* from Saros Bay (Northern Aegean Sea, Turkey).

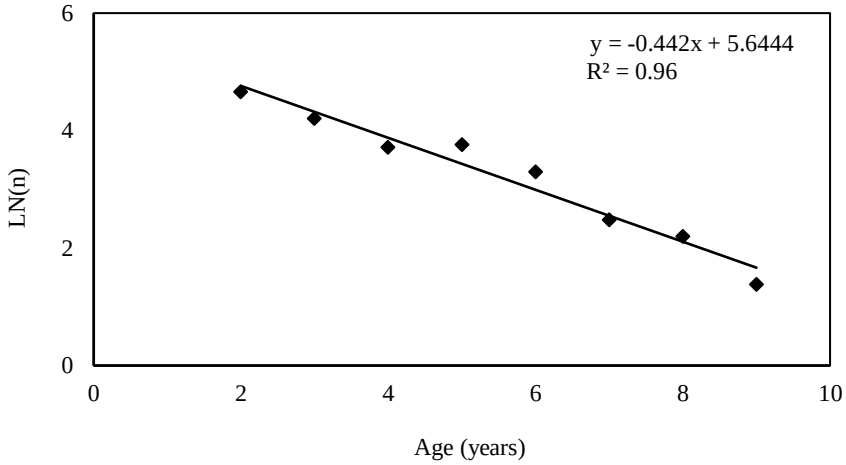

Figure 5. Age structured catch curve for estimation of total mortality (Z) of *Boops boops* from Saros Bay (Northern Aegean Sea, Turkey).

DISCUSSION

Table 2 summarizes the results about the length-weight relationships (LWRs) between the present study to previous ones.

The *b* values in LWRs falls between 2.5 and 3.5 (Froese 2006) or 2 to 4 (Tesch 1971). In this study, the *b* value of *B. boops* was within these expected ranges. Generally, the *b* value obtained from LWR estimation within the same species can change depending on the degree of gonad maturity, sex, diet, sample preservation techniques, stomach fullness (Wootton 1990), number of specimens analyzed, area/season effects, sampling duration (Moutopoulos and Stergiou 2002), fishing gear used (Kapiris and Klaoudaos 2011), and size selectivity of the sampling gear (İşmen et al. 2007). For these reasons, Torres et al. (2012) underlined that LWRs may change temporarily and/or spatially, so these studies should be regularly updated for each separate population.

The mean lengths at different ages for *B. boops* given by various authors are listed in Table 3. However, Table 4 indicates the maximum ages, growth parameters and growth performance indices of *B. boops* reported in Mediterranean Basin.

The maximum age of the bogue was reported as 11 years by Girardin and Quignard (1986) in the Gulf of Lion and 13 years by Khemiri et al. (2005) in eastern Tunisian coasts. The maximum ages can vary widely among the populations within species especially those that have wide distributions (Gibson 2005). In this case, the reasons for differences in longevity could be attributed to the effects of temperature, intensities of competition for food, food availability, life history strategies, and fishing efforts (Nash and Geffen 2005). Within the Mediterranean Sea, there exists a west-east gradient (Krom et al. 1991). The Eastern Mediterranean has been identified as one of the most oligotrophic areas of the world (Azov 1986; Paruğ and Cengiz 2020b). These values from the western Mediterranean areas are the highest one compared to all other eastern Mediterranean values. This may be because the eastern Mediterranean is one of the most oligotrophic areas of the world. The differences in growth parameters among the study areas could probably be attributed to a combination of sample characteristics (sample sizes and range of sizes), geographical differences and aging methodology used (Monterio et al. 2006), incorrect age interpretation (Matić-Skoko et al. 2007; Bayhan et al. 2008), size, quantity and quality of food and water temperature (Santic et al. 2002), and differences in length at first maturity (Champagnat 1983). Besides, the selectivity of the fishing tool used can also affect the estimates of growth parameters (Ricker 1969; Potts et al. 1998). Therefore, the possible reasons for the differences in the results between the other studies and this study may be related to one or more factors given above. Table 5 documents the previous studies on length at first maturity of *B. boops* from different areas.

The length at first maturity from asymptotic length by using the empirical relationship has been calculated by many authors (Ateş et al. 2008; Cengiz 2013; Hossain et al. 2013; Kindong et al. 2019, etc.). The differences in lengths at first maturity between different areas could be attributed to food availability and temperature (Nikolsky 1963; Hempel 1965), overfishing pressure and selectivity (Trippel 1995; Helser and Almeida 1997; Jennings et al. 2001), genetic factors (Wootton 1998), and the use of different methods (Trippel and Harvey 1991; Froese and Binohlan 2000). Table 6 reports the results of earlier studies concerning mortality rates of *B. boops* from different areas.

Table 2. Comparision of length-weight relationships of *B. boops* in Mediterranean Basin. ♀ = Female, ♂ = Male, Σ = All samples, N = Sample size; *a* and *b* = the parameters of the relationships

References	Location	Sex	N	Length range (cm)	*a*	*b*
Petrakis and Stergiou (1995)	south Euboikos Gulf (Greece)	Σ	256	9.6 – 24.3	0.000012	3.09
Çiçek et al. (2006)	Babadıllimanı Bight (Turkey)	Σ	391	7.5 – 21.4	0.0080	3.04
Karakulak et al. (2006)	Gökçeada Island (Turkey)	♂	213	15.3 – 27.8	0.0074	3.11
		♀	232	15.4 – 32.1	0.0032	3.39
Manaşırlı et al. (2006)	Babadıllimanı Bight (Turkey)	Σ	314	7.5 – 21.4	0.0084	3.03
İşmen et al. (2007)	Saros Bay (Turkey)	Σ	189	10.5 – 22.0	0.0045	3.24
Bilge et al. (2008)	İzmir Bay (Turkey)	Σ	1245	9.5 – 27.1	0.0065	3.10
	Edremit Bay (Turkey)	Σ	1150	9.3 – 28.1	0.0041	3.32
Cherif et al. (2008)	Gulf of Tunis (Tunisia)	Σ	243	12.0 – 26.0	0.0070	3.06
El-Okda (2008)	Alexandria (Egypt)	Σ	920	-	0.0254	2.66
Hajjej et al. (2010)	Gulf of Gabes (Tunisia)	Σ	346	12.6 – 22.6	0.0102	3.03
Ramdene et al. (2013)	Bejaia (Algeria)	♂	-	-	0.0130	2.81
		♀	-	-	0.0150	2.77
Rachid et al. (2014)	B0u-Ismail Bay (Algeria)	Σ	1372	9.0 – 29.0	0.0160	2.79
Houria and Abdellatif (2015)	between Tenes and Tlemcen (Algeria)	Σ	2068	9.7 – 27.4	0.0039	3.26
Kara and Bayhan (2015)	İzmir Bay (Turkey)	♂	429	12.2 – 27.0	0.0028	3.42
		♀	503	11.3 – 27.9	0.0069	3.12
Soykan et al. (2015)	İzmir Bay (Turkey)	Σ	421	11.0 – 23.8	0.0050	3.25
Kherraz et al. (2016)	Oran (Algeria)	♂	496	9.0 – 26.0	0.0130	2.86
		♀	578	11.2 – 32.3	0.0120	2.88
Kara et al. (2018)	Gediz Estuary (Turkey)	Σ	51	8.5 – 13.8	0.0092	2.02
Azab et al. (2019)	Alexandria (Egypt)	♂	683	9.3 – 21.6	0.0100	2.97
		♀	684	10.0 – 23.1	0.0120	2.91
Dahel et al. (2019)	from Cap Takouch to Ain B'Har (Algeria)	Σ	1734	10.1 – 30.9	0.0016	2.81
Cengiz et al. (2019)	Saros Bay (Turkey)	♂	564	13.7 – 25.6	0.0095	3.07
		♀	374	13.4 – 27.6	0.0085	3.11
Milled-Fathalli et al. (2019)	Gulf of Tunis (Tunisia)	Σ	45	12.5 – 21.0	0.0119	2.88
Babaoğlu et al. (2021)	Çandarlı Bay (Turkey)	Σ	65	6.8 – 13.8	0.0094	3.01
This study	Saros Bay (Turkey)	Σ	363	11.3 – 24.1	0.0080	3.13

The discrepancies between the mortality rates from different areas could probably be attributed to various factors such as different ecological conditions and intensive fishing activities between the localities, and employed various methods (Joksimović et al. 2009). In this study, the low exploitation rate (E) indicated that bogue is not subjected to the fishing pressure. There are two reasons for this case: (1) As the bay had been closed to bottom trawl fishing since 2000, there is no overfishing on bogue; (2) Kumova et al. (2015) stressed that the nets used with drive-in fishery method did not give rise to the fishing pressure on bogue population.

Table 3. The mean lengths at different ages for of *Boops boops* estimated by different ageing methods from some localities in Mediterranean Basin. *from Bilge (2008), **from El - Okda (2008), ♀ = Female, ♂ = Male, Σ = All samples.

References	Location	Ageing Method	Sex	Age (years)										
				0	1	2	3	4	5	6	7	8	9	10
Alegría-Hernández (1989)**	Central Adriatic Sea (Croatia)	Otolith	Σ	-	-	14.7	17.7	20.0	22.0	23.8	-	-	-	-
		Length-frequency	Σ	-	-	14.1	17.0	19.4	21.5	23.2	-	-	-	-
Girardin and Quignard (1986)*	Gulf of Lyon	Scale	Σ	-	9.1	14.2	17.4	20.4	22.5	24.3	25.7	27.4	28.6	29.6
Hassan (1990)**	Egypt	Scale	Σ	-	10.2	13.3	15.9	18.3	20.2	21.7	-	-	-	-
Öztürk (1998)*	İzmir Bay (Turkey)	-	Σ	-	12.8	14.8	17.2	19.1	-	-	-	-	-	-
Abdel-Rahman (2003)**	Alexandria (Egypt)	Scale	Σ	-	9.3	11.3	13.3	14.9	16.4	17.9	-	-	-	-
Allam (2003)**	Alexandria (Egypt)	Scale	Σ	-	11.0	14.0	16.3	18.6	20.5	-	-	-	-	-
El-Haweet et al. (2005)**	from Matrouh city to Saloum Bay (Egypt)	Scale	Σ	-	9.7	12.9	15.5	17.6	19.5	21.4	-	-	-	-
		Length-frequency	Σ	-	9.5	13.4	16.2	18.4	20.5	22.5	-	-	-	-
Khemiri et al. (2005)*	eastern Tunisian coasts	Otolith	Σ	-	11.5	14.4	17.0	19.0	20.5	22.0	-	-	-	-
	northern Tunisian coasts	Otolith	Σ	-	12.0	15.0	17.8	19.9	21.6	23.1	-	-	-	-
Manaşırlı et al. (2006)	Babadıllimanı Bight (Turkey)	Otolith	Σ	-	8.5	11.7	13.4	14.8	17.1	19.2	-	-	-	-
Bilge (2008)	İzmir Bay (Turkey)	Otolith	Σ	10.1	12.9	15.2	16.1	18.4	19.9	21.3	22.1	22.9	24.9	-
	Edremit Bay (Turkey)	Otolith	Σ	10.2	13.0	15.7	16.9	18.5	20.0	21.5	22.3	23.0	25.1	-
El - Okda (2008)	Alexandria (Egypt)	Otolith	Σ	-	9.5	12.6	15.0	17.0	-	-	-	-	-	-
Rachid et al. (2014)	B0u-Ismail Bay (Algeria)	Length-frequency	Σ	-	13.8	17.1	21.4	24.7	27.4	-	-	-	-	-
Houria and Abdellatif (2015)	between Tenes and Tlemcen (Algeria)	Otolith	Σ	-	10.7	13.7	15.2	16.3	17.7	19.3	21.0	22.1	22.4	-
Kara and Bayhan (2015)	İzmir Bay (Turkey)	Otolith	♂	-	11.3	15.2	18.4	21.1	22.8	-	-	-	-	-
			♀	-	11.2	15.1	18.7	21.4	23.1	-	-	-	-	-
Azab et al. (2019)	Alexandria (Egypt)	Scale	Σ	-	8.4	13.8	17.9	21.0	-	-	-	-	-	-
Dahel et al. (2019)	from Cap Takouch to Ain B'Har (Algeria)	Length-frequency	Σ	-	14.4	17.4	20.5	24.5	29.3	-	-	-	-	-
This study	Saros Bay (Turkey)	Otolith	Σ	-	13.0	14.4	17.0	18.6	20.0	21.3	21.9	22.6	23.3	-

Table 4. The results of maximum ages, growth parameters and growth performance indices obtained from previous studies for *Boops boops* in Mediterranean Basin. * from Monterio et al. (2006), **from Bilge (2008), ***from El-Haweet et al. (2005), +Φ' was calculated, ♀ = Female, ♂ = Male, Σ = All samples, L_∞ = theoretical asymptotic length, K = growth rate coefficient, t_0 = theoretical age when fish length is zero, Φ' =growth performance index.

References	Location	Ageing Method	Sex	L_∞	K	t_0	Age range (year)	Φ'
Girardin (1981)*	Gulf of Lyon	Otolith	Σ	46.5	0.08	-3.54	0 - 7	2.54
Anato and Ktari (1983)*	Tunisia	Otolith	Σ	39.6	0.11	-1.69	1 - 8	2.24
Alegría-Hernández (1989)***	Central Adriatic Sea (Croatia)	Otolith	Σ	33.2	0.17	-1.48	2 - 6	2.28
		Length-frequency	Σ	33.9	0.16	-1.46	2 - 6	2.20
Girardin and Quignard (1986)*	Gulf of Lyon	Scale	Σ	33.5	0.19	-0.75	1 - 11	2.34
Djabali et al. (1990)	Beni-Saf (Algeria)	Length-frequency	♀	27.3	0.22	-1.94	-	2.21
			♂	26.6	0.21	-2.60	-	2.17
Hassan (1990)***	Egypt	Scale	Σ	29.8	0.18	-1.33	1 - 6	2.20
Tsangridis and Filippousis (1991)	Grecee	Length-frequency	Σ	36.0	0.40	-	-	2.71
+Öztürk (1998)**	İzmir Bay (Turkey)	-	Σ	34.6	0.15	1.71	1 - 4	2.25
Abdel-Rahman (2003)***	Alexandria (Egypt)	Scale	Σ	33.5	0.09	-2.64	1 - 6	2.00
Allam (2003)***	Alexandria (Egypt)	Scale	Σ	37.1	0.15	-1.78	1 - 5	2.19
El-Haweet et al. (2005)	from Matrouh city to Saloum Bay (Egypt)	Scale	Σ	31.9	0.15	-1.53	1 - 6	2.18
		Length-frequency	Σ	29.7	0.25	-0.70	1 - 6	2.34
+Khemiri et al. (2005)	eastern Tunisian coasts	Otolith	Σ	26.7	0.22	-1.43	1 - 13	2.20
	northern Tunisian coasts	Otolith	Σ	28.7	0.20	-1.41	1 - 9	2.22
+Manaşırlı et al. (2006)	Babadıllimanı Bight (Turkey)	Otolith	Σ	33.6	0.10	-1.90	1 - 6	2.05
+Bilge (2008)	İzmir Bay (Turkey)	Otolith	Σ	32.1	0.12	-3.20	0 - 9	2.09
	Edremit Bay (Turkey)	Otolith	Σ	31.5	0.13	-3.11	0 - 9	2.11
El - Okda (2008)	Alexandria (Egypt)	Otolith	Σ	30.1	0.15	-1.50	1 - 6	2.14
Ramdene et al. (2013)	Bejaia (Algeria)	Otolith	♂	27.0	0.24	-1.53	-	2.24
			♀	27.5	0.28	-1.20	-	2.32
Rachid et al. (2014)	B0u-Ismail Bay (Algeria)	Length-frequency	Σ	29.6	0.33	-	1 - 5	2.46
Houria and Abdellatif (2015)	between Tenes and Tlemcen (Algeria)	Otolith	Σ	30.0	0.11	-2.91	1 - 9	2.00
Kara and Bayhan (2015)	İzmir Bay (Turkey)	Otolith	♂	29.8	0.24	-0.98	1 - 5	2.34
			♀	30.7	0.23	-0.90	1 - 5	2.37
Layachi et al. (2015)	coastal area of Nador-Saïdia (Morocco)	Length-frequency	Σ	30.0	0.41	-0.30	-	2.54
Soykan et al. (2015)	İzmir Bay (Turkey)	Otolith	Σ	29.5	0.26	-1.14	1 - 5	2.37
Kherraz et al. (2016)	Oran (Algeria)	Length-frequency	♂	26.7	0.38	-0.75	-	2.43
			♀	34.1	0.26	-1.50		2.48

References	Location	Ageing Method	Sex	L_∞	K	t_0	Age range (year)	Φ'
Azab et al. (2019)	Alexandria (Egypt)	Scale	Σ	30.6	0.27	-0.16	1 - 4	2.42
Dahel et al. (2019)	from Cap Takouch to Ain B'Har (Algeria)	Length-frequency	Σ	32.3	0.28	-0.58	1 - 5	2.46
This study	Saros Bay (Turkey)	Otolith	Σ	27.9	0.21	-1.57	1 - 9	2.21

Table 5. Previous studies on lengths at first maturity of *Boops boops* from different areas in Mediteranean Basin. *from Layachi et al. (2015), ♀ = Female, ♂ = Male

References	Location	Length at first maturity (cm)
Matta (1958)*	Tuscan Archipelago (Italia)	13.0 (♀) - 11.6 (♂)
Mouneime (1981)*	Lebanon	13.0
Ktari and Anato (1983)*	Tunusia	14.0 to 18.0
Chali Chabane (1988)*	Bou Ismail (Algeria)	13.5
Meguedad and Mahious (1989)*	Oran (Algeria)	13.2
Hassan (1990)*	Egypt	10.0 to 13.0
El Agamy et al. (2004)*	Egypt	12.0 (♀) - 13.0 (♂)
Kherraz (2011)*	Oran (Algeria)	17.1
Bottari et al. (2014)	southern Tyrrhenian Sea (Italia)	13.1 (♀) - 14.2 (♂)
Layachi et al. (2015)	coastal area of Nador-Saïdia (Morocco)	14.3 (♀) - 13.3 (♂)
Soykan et al. (2015)	İzmir Bay (Turkey)	12.9 (♀) - 9.3 (♂)
Amira et al. (2019)	central Algerian coast	14.7
This study	Saros Bay (Turkey)	16.6

Table 6. Results of earlier studies concerning mortality rates of *Boops boops* from different areas in Mediterranean Basin.

References	Location	Z	M	F	E
Allam (2003)	Alexandria (Egypt)	1.28	0.45	0.82	0.46
Manaşırlı et al. (2006)	Babadıllimanı Bight (Turkey)	1.25	0.35	0.90	0.72
Houria and Abdellatif (2015)	between Tenes and Tlemcen (Algeria)	0.41	0.24	0.18	0.43
Soykan et al. (2015)	İzmir Bay (Turkey)	1.17	1.15	1.02	0.87
Dahel et al. (2019)	from Cap Takouch to Ain B'Har (Algeria)	1.03	0.37	0.66	0.64
This study	Saros Bay (Turkey)	0.44	0.38	0.06	0.13

In conclusion, efficient fisheries management and enforcement regulations are known to be necessary to protect natural resources and provide their sustainability. Regular monitoring of the stock status is vital for optimal fishing and stock management, both related to sustainable fisheries (Kara and Bayhan 2015). For these reasons, the molecular characterisation and stable isotope analysis (using otoliths) of bogue must be made to determine if there is a single stock or more in Turkish waters. This may ensure knowledge on whether there may be two or more genetically distinct stocks that may have overlapping distributions. And what's more, it should be carried out into the early life history of the fish to determine otolith microstructure, spawning periodicity, dietary habits of larvae and map out nursery grounds as well as migratory routes. The results of the present study deal with the age and growth of *B. boops* to obtain growth parameters estimation, which are significant input parameters to stock assessment techniques and shall provide an insight into the life history of bogue. Further investigations and longer-term sampling studies should be required to certify this first evaluation. Nonetheless, the available information must be taken

into account to make a contribution to fishery managers and international scientific literature.

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Jigsaw strategy: strengthening achievement and interest in mathematics among elementary pre-service teachers

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ABSTRACT

Mathematics is considered one of the most challenging courses for many elementary pre-service teachers (EPTs). In hopes for improvement, teacher educators have been incorporating a jigsaw strategy to equip future teachers with the necessary competencies. Hence, the study aimed to determine the effectiveness of the jigsaw strategy with EPTs' level of mathematics achievement and interest in an online cooperative learning environment. The research utilized a pre-experimental design with 40 participants. The researchers used pretest and posttest questions covering fraction operations and a mathematics interest questionnaire before and after the intervention. With the implementation of the jigsaw strategy, results showed that the EPTs' mathematics achievement improved while their interest in mathematics improved to some extent. Likewise, a significant difference between the pre-and post-intervention concerning the EPTs' mathematics achievement and interest in mathematics was found. Furthermore, correlation analysis revealed that study time is negatively related to mathematics achievement, as is the overall level of interest in mathematics. These findings imply that a jigsaw strategy is a useful tool in teaching mathematics online. However, several modifications may be considered to recognize that the EPTs' interest in mathematics varies from one person to another. Teacher education institutions are encouraged to apply this strategy not only for EPTs to increase their mathematical know-hows but also to serve as an example for them to employ in their future teaching careers.

Keywords: cooperative learning, fractions, mathematics education, prospective teachers, teacher education institution

INTRODUCTION

Filipino elementary pre-service teachers (EPTs) find mathematics as a challenging endeavor (Domingo et al. 2021; Pentang et al. 2021), which is attributed to the EPTs' dislike for mathematics (Ibañez and Pentang 2021). Dislike for mathematics contribute to loss of interest and underperformance in the subject (Areelu and Ladele 2018), where low interest in mathematics has a direct impact on motivation to complete activities. These factors challenged mathematics educators on how they could help EPTs appreciate and perform better in the subject. Some researchers used cooperative learning strategies to address this problem (Mbacho and Changeiywo 2013; Timayi et al. 2015; Johnson and Johnson 2018; Yemi et al. 2018; Ibañez and Pentang 2021).

Cooperative learning begins in a small group who is equally accountable and share the rewards and even failures; has a positive effect on the learner's motivation to complete a task while developing a greater sense of belongingness and accomplishment; and derives its strength from positive interdependence, interaction, and accountability (Garcia et al. 2017; Johnson and Johnson 2018). Among the various cooperative learning strategies, the jigsaw is an effective strategy. Jigsaw strategy was first introduced in the classroom in 1971 (Aronson 2000). This strategy was designed for small groups of learners that gives them a chance to become an 'expert' in a specific lesson.

The utilization of the jigsaw teaching strategy resulted in enhanced performance in mathematics (Aronson 2000; Mbacho and Changeiywo 2013; Russo 2014; Okeke 2015; Garcia et al. 2017; Areelu and Ladele 2018; Casing 2018; Yemi et al. 2018; Abed et al. 2020; Okafor and Nwosu 2021; Ummah and Hamna 2021). For learners, the jigsaw strategy provided them opportunities to express themselves and process information, which can improve both their abilities and learning outcomes (Timayi et al. 2015; Areelu and Ladele 2018; Yozza et al. 2018; Abed et al. 2020). However, research on the effectiveness of jigsaw strategy in an online environment to enhance mathematics achievement and interest in the

Philippines is limited, especially in the context of the EPTs.

The EPTs' mathematics achievement was relatively poor as it can be influenced by a lot of factors (Domingo et al. 2021; Ibañez and Pentang 2021; Pentang et al. 2021). Interest in mathematics is one of the contributing factors in the EPTs' performance towards the subject. With the implementation of online learning, EPTs are facing an additional burden in learning mathematics as technical difficulties could contribute to their frustration towards the subject. Teachers are also limited in utilizing cooperative learning techniques during online classes since overseeing them requires more effort. As future teachers, the mathematics achievement and interest of the EPTs can provide insights on how they perform in the subject with the help of jigsaw strategy in an online setting. With this, the study ascertained the effectiveness of the jigsaw strategy in enhancing mathematics achievement and interest in an online environment among EPTs. Specifically, this determined and compared their level of mathematics achievement and interest before and after the intervention; and determined the relationships between their mathematics achievement and interest after the intervention.

Jigsaw strategy fosters a positive learning environment in which EPTs develop a strong sense of responsibility in their learning, strengthen camaraderie among themselves, and become experts on a specific topic. As a result, this study would benefit EPTs not only in appreciating mathematics but also in embracing the essence of collaborative learning and its impact on academic achievement. In addition, curriculum developers and teacher educators can use the findings of this study to consider incorporating the jigsaw strategy into the revision of the mathematics curriculum. The jigsaw strategy can further the promotion of mathematics by making it more appealing to EPTs who typically dislike the subject.

METHODS

Research Design

A pre-experimental design was employed to determine the effect of using jigsaw strategy in enhancing the EPTs' mathematics achievement and interest in mathematics. Pre-experimental design involves observing a group after an intervention has been administered to determine whether the intervention has the potential to cause change (Frey 2018). The researchers and an external expert served as observers and validators of the jigsaw strategy intervention. The current study is the first of three phases of a continuing intervention. The first phase is limited to a two-week implementation. The second and third phases will be four and six weeks, respectively. In the end, these three will be evaluated.

Participants and Sampling Procedure

Employing total population sampling, 40 EPTs of Central Luzon State University enrolled in Teaching Mathematics in Intermediate Grades served as the participants of the study, given a small population. Approved consent was secured from the authorities and participants before gathering pertinent data for the study. The participants volunteered to take part in the study, and their participation had nothing to do with their grades.

Data Gathering Procedure

For the pre-intervention stage, a 30-item pretest was modified from Ibañez and Pentang (2021) and the 27-item Student's Mathematics Interest Questionnaire (SMIQ) from Stevens and Olivarez (2005) were employed to determine the EPTs' mathematics achievement and interest before the jigsaw intervention. The pretest included (a) basics of fractions, (b) adding/subtracting similar fractions, dissimilar fractions, and mixed numbers, and (c) multiplication and division of fractions and mixed numbers. The SMIQ was divided into three groups – positive valence, negative valence, and time. The use of these instruments was permitted by the developers. Excellent test-retest reliability coefficients (> 0.9) were obtained, and the instruments were validated by mathematics education experts.

The intervention stage comes next. This stage was the deployment of the jigsaw strategy on the teaching-learning process for two meetings. The first meeting covered the topics of basics of fractions, adding/subtracting similar fractions, dissimilar fractions, and mixed numbers. the second meeting was composed of multiplication and division of fractions and mixed numbers. Both meetings have an hour and a half to execute the jigsaw strategy.

Each meeting was conducted in a synchronous delivery through Google Meet. The assembly group was the first meeting to designate their respective home groups, the participants then join a meeting according to their homegroup. After designating specific topics for each member in the homegroup, the participants then join a meeting based on their specific topic, that is, their expert group. After they master their topic, they returned to their original homegroup to discuss the lesson with their classmates. Then, when everyone is done, they all return to the assembly group to wrap things up.

Finally, the post-intervention stage. A posttest was administered to assess the effectiveness of the intervention on enhancing mathematics achievement, together with the SMIQ to determine

significant differences in the interest in mathematics after the implementation of the jigsaw strategy.

Data Analysis

Data gathered were analyzed using arithmetic means and standard deviation in describing the mathematical achievement and interest of the participants before and after the intervention, respectively. A paired-sample t-test was used to ascertain the significant differences concerning the mathematics achievement and interest of the participants before and after the intervention while Pearson product-moment correlation was employed to establish significant relationships between their mathematics achievement and interest after the intervention.

RESULTS

Elementary Pre-service Teachers' Level of Mathematics Achievement

The EPTs achieved satisfactory pretest, while they obtained an outstanding posttest score. Specifically, the EPTs performed poorly to satisfactory during the pre-test, and very satisfactorily to outstanding after the implementation of the jigsaw strategy, correspondingly (Table 1). The posttest score was significantly higher than the pretest score after employing the jigsaw intervention ($P < 0.001$).

Elementary Pre-service Teachers' Level of Interest in Mathematics

The EPTs' overall interest in mathematics before the intervention was moderate but increased after the intervention. The positive valence before the intervention was moderate, while the positive valence after the intervention was high. In terms of negative valence and time, the pre-and post-intervention interests of the EPTs were moderate (Table 2).

The EPTs' overall interest in mathematics during the post-intervention was significantly higher than the pre-intervention, $t_{(8)} = -4.419$, $P < 0.001$ (Table 3). Besides, the positive attraction towards mathematics was reported to have a significant difference as well, $t_{(8)} = -3.441$, $P < 0.01$. The post-intervention of the positive valence was more likely to have a higher positive attraction in mathematics compared to their pre-intervention positive attraction. However, negative valence and study time showed no significant difference before and after the intervention.

Relationship between the Elementary Pre-service Teachers' Interest and Mathematics Achievement

Study time was negatively related to mathematics achievement of the EPTs ($r = -0.338$, $P < 0.05$). Similarly, overall interest in mathematics was negatively related to mathematics achievement ($r = -0.177$, $P < 0.05$). On the other hand, positive and negative valence were not significantly related to mathematics achievement (Table 4).

Table 1. Elementary pre-service teachers' level of mathematics achievement. Note: 24.01-30.00 = outstanding, 18.01-24.00 = very satisfactory, 12.01-18.00 = satisfactory, 6.01-12.00 = unsatisfactory, 0.00-6.00 = poor.

Topic	Pretest		Posttest	
	Mean	SD	Mean	SD
Adding/Subtracting Similar Fractions	18.00	9.90	26.50	2.12
Adding/Subtracting Dissimilar Fractions	18.67	11.68	29.01	1.41
Adding/Subtracting Mixed Numbers	15.25	8.61	24.82	6.03
Multiplication and Division of Fractions	10.08	6.20	21.50	6.36
Multiplication and Division of Mixed Numbers	5.25	6.13	18.25	4.72
Overall Achievement	13.45	8.08	24.02	6.59

Table 2. Elementary pre-service teachers' level of interest in mathematics. Note: 6.15-7.00=very true of me, 5.29-6.14=true of me, 4.43-5.28=somewhat true of me, 3.58-4.42=not sure, 2.72-3.57=somewhat not true of me, 1.86-2.71=not true of me, 1.00-1.85=not at all true of me. 4.67-7.00=high interest, 2.34-4.66=moderate interest, 1.00-2.33=low interest

PARAMETERS	Pre-intervention			Post-intervention		
	Mean	SD	Description	Mean	SD	Description
Positive Valence	4.58	0.76	Moderate Interest	4.94	0.96	High Interest
1. I like to answer questions in mathematics class.	3.88	1.34	Not sure	3.98	1.37	Not sure
2. I like mathematics.	4.18	1.36	Not sure	4.13	1.45	Not sure
3. I am interested in mathematics.	4.53	1.38	Somewhat true of me	4.68	1.35	Somewhat true of me

PARAMETERS	Pre-intervention			Post-intervention		
	Mean	**SD**	**Description**	**Mean**	**SD**	**Description**
4. Knowing a lot about mathematics is helpful.	5.70	1.45	True of me	6.23	1.00	Very true of me
5. I feel good when it comes to working on mathematics.	4.13	1.26	Not sure	4.20	1.36	Not sure
6. I want to know all about how to do mathematics problems.	5.35	1.51	True of me	5.80	1.24	True of me
7. I feel excited when a new mathematics topic is announced.	3.88	1.24	Not sure	4.05	1.47	Not sure
8. I want to learn more about mathematics.	5.60	1.50	True of me	6.18	1.20	Very true of me
9. I choose to work on mathematics.	4.03	1.35	Not sure	4.28	1.43	Not sure
10. I want to know all about mathematics.	5.38	1.53	True of me	5.90	1.17	True of me
Negative Valence	3.95	0.60	Moderate interest	4.27	0.82	Moderate interest
1. I am wasting my time on mathematics.	3.05	1.75	Somewhat not true of me	2.68	1.67	Somewhat not true of me
2. I am bored when working on mathematics.	3.63	1.41	Not sure	3.83	1.52	Not sure
3. I would rather be working on something else besides mathematics.	4.25	1.41	Not sure	4.35	1.82	Not sure
4. I give up easily when working on mathematics.	4.03	1.80	Not sure	3.93	1.80	Not sure
5. When working on mathematics, I want to stop and start working on something else.	4.13	1.64	Not sure	4.28	1.75	Not sure
6. I am always thinking of other things when working on mathematics.	4.03	1.56	Not sure	4.10	1.66	Not sure
7. I get mad easily when working on mathematics.	3.70	1.64	Not sure	4.23	1.44	Not sure
8. I have difficulty paying attention when working on mathematics.	4.63	1.33	Somewhat true of me	5.20	1.52	Somewhat true of me
9. I spend as little time as possible working on mathematics.	4.13	1.42	Not sure	4.35	1.73	Not sure
10. I struggle with mathematics.	5.30	1.60	Somewhat true of me	5.80	1.16	True of me
Time	4.35	0.54	Moderate interest	4.50	0.68	Moderate interest
1. I work more on mathematics problems than I have to.	3.80	1.20	Not sure	3.80	1.52	Not sure
2. I spend many hours working on mathematics.	4.93	1.29	Somewhat true of me	5.33	1.56	True of me
3. I work on mathematics in my spare time.	4.03	1.42	Not sure	3.88	1.40	Not sure
4. I want to talk about mathematics with my friends.	4.20	1.42	Not sure	4.53	1.73	Somewhat true of me
5. I spend more time than most of my classmates working on mathematics.	4.38	1.21	Not sure	4.83	1.60	Somewhat true of me
6. I prefer easy mathematics over mathematics that is hard.	5.23	1.75	Somewhat true of me	5.33	1.42	True of me
7. I am too involved in mathematics.	3.88	1.47	Not sure	3.85	1.72	Not sure
OVERALL MEAN	4.37	0.67	Moderate interest	4.58	0.86	Moderate interest

Table 3. Difference between the elementary pre-service teachers' interest in mathematics.

Mathematics Interest	Mean	SD	df	t	*P*
Positive Valence					
Pre-Intervention	4.58	0.76	8	-3.441	0.009
Post-Intervention	4.83	0.95			
Negative Valence					
Pre-Intervention	3.95	0.45	8	-1.577	0.153
Post-Intervention	4.10	0.66			
Time					
Pre-Intervention	4.35	0.54	6	-1.777	0.126
Post-Intervention	4.50	0.68			
Overall Interest					
Pre-Intervention	4.37	0.67	26	-4.419	0.000
Post-Intervention	4.58	0.86			

Table 4. Relationship between the elementary pre-service teachers' interest and mathematics achievement. *Correlation is significant at the 0.05 level (2-tailed).

Pearson Correlation	Positive Valence		Negative Valence		Time		Over-all Interest	
	r	*P*	*r*	*P*	*r*	*P*	*r*	*P*
Posttest	-0.242	0.133	0.021	0.899	-0.338*	0.033	-0.177*	0.027

DISCUSSION

Elementary Pre-service Teachers' Level of Mathematics Achievement

The EPTs' mathematics achievement before the intervention is weak which implies that the future teachers were not able to answer the pretest covering operations on fractions. However, it was evident that there is an increase in the number who got an average mark after the intervention. Meanwhile, it is interesting to point out that the EPTs' were able to get an excellent and above-average mark after the intervention. The jigsaw strategy indeed strengthened the mathematics achievement of the EPTs. It coincides with the findings of Casing (2018) where more EPTs' got higher marks after the implementation of the jigsaw strategy and conforms to Ibañez and Pentang (2021) which resulted that cooperative learning strategy can improve EPTs' achievement in fractions. Russo (2014) and Okeke (2015) also reported that students' performance was improved when mathematics was taught using the jigsaw strategy. This result shows that EPTs can utilize jigsaw strategy in the teaching-learning process even with fractions. Thus, by exchanging ideas, EPTs will have a better sense of responsibility for their learning and their peers.

Jigsaw strategy allows the EPTs to become an expert in a specific topic. After they became experts on a specific topic, they were able to share their knowledge with their peers. Hence, from a single knowledge, they were able to gain additional learnings from among themselves. Instead of memorizing just one step in addition or subtraction of fractions, the EPTs have now learned new and simpler methods of solving problems. Also, the jigsaw strategy promotes cooperation among them. Some lessons are difficult, and they were terrified to ask their teachers for clarifications. This results in unclear or lack of mastery towards the lesson. In the jigsaw strategy, EPTs can easily ask their peers for clarifications as they see them as their equal, where it was evident the differences between before and after the intervention were found significant. Though fraction operations are confusing for many, it was easier for students who work together compared to individual learning through modules or video tutorials (Abed et al. 2020), which is predominant in today's online class setup.

This result was comparable with Anaduaka et al. (2018) when the experimental group displayed a significant increase in their academic achievement in mathematics which means that the utilization of the jigsaw strategy is highly effective for instruction. This shows that the utilization of the jigsaw strategy in mathematics class, even though online class, benefitted the EPTs in strengthening their achievement. It can also be construed that the use of the jigsaw strategy is effective even in an online learning environment where internet connectivity can be a problem. Abed et al. (2020) reported a similar result after they investigated the predicting effects of

jigsaw strategy in proficiency in mathematics where the test scores of those in the jigsaw group increased significantly than those in the teacher-centered group. Additionally, Mbacho and Changeiywo (2013) and Yemi et al. (2018) revealed that students who were subjected to the jigsaw strategy scored better in the posttest as compared to their pretest score. Considerably, pedagogical interventions can enhance mathematics achievement (Pentang 2021) and a jigsaw strategy can help in strengthening the knowledge and skills in mathematics. Thus, training should be designed for mathematics teachers on the appropriate usage of the strategy rather than focusing on the traditional method of teaching. EPTs will be having more hands-on experience in understanding a specific topic in mathematics that will then be converted into better outputs and achievement.

Elementary Pre-service Teachers' Level of Interest in Mathematics

The EPTs developed a more positive attraction towards mathematics after the intervention since they expressed their feelings on how helpful their knowledge in mathematics can be and that they were willing to learn more about the subject. This is parallel with Oduro et al. (2014) where most participants showed a strong affinity for mathematics. In physics, students improved their interest as they developed critical thinking and they became more responsible for the success of their group (Kade et al. 2019). However, this finding showed setbacks in terms of excitement in learning new topics and answering questions about mathematics after the jigsaw strategy intervention. These setbacks may be influenced by the EPTs' unfamiliarity with jigsaw strategy or the observation that they have poor mathematical interest.

The jigsaw strategy failed to decrease the negative attitude of the EPTs. It also shows that EPTs developed a negative attraction towards the subject. Negative attraction towards the subject could stem from the frustration brought by slow internet connectivity and online learning adds up to the stress in learning mathematics. This finding is comparable with Wong and Wong (2019) where some participants agreed that they are wasting time on mathematics, while others perceived that they get mad easily when working on mathematics.

Generally, the findings implied that the jigsaw strategy slightly increased the EPTs' interest in mathematics. It means that the participants develop a higher level of interest in mathematics after they were subjected to the intervention. This result can be attributed to the fact that the jigsaw strategy helped in the development of cooperation among EPTs. Similarly, Okeke (2015) and Areelu and Ladele (2018) noted that those who were subjected to the jigsaw strategy had increased their level of interest in mathematics.

The EPTs' interest in mathematics was enhanced when the jigsaw strategy was used in teaching fraction operations. The EPTs were able to motivate each other during the jigsaw strategy intervention since they can discuss the topic with their peers in jigsaw strategy, as compared to traditional teaching where learners must listen attentively to the discussions of the teacher. Similarly, Oduro et al. (2014) reported that the majority of the participants do not like the traditional approach and methods employed by the teachers in teaching mathematics. Breaking the learners into smaller groups also helps in developing camaraderie. Learners become more interested in mathematics when they are divided into small groups. Timayi et al. (2015) reported a similar result when their study revealed a significant difference in the interest level of the EPTs when exposed to the jigsaw strategy. Moreover, Areelu and Ladele (2018) found out that the jigsaw strategy was an effective method of teaching to improve the mathematics interest among learners. This implies that the jigsaw strategy can help the EPTs develop an appreciation of mathematics since they will be handling the same to their future students. Furthermore, the jigsaw strategy is effective in increasing student involvement and understanding towards the subject thus creating more fun and positive environment for learning mathematics (Yozza et al. 2018).

The jigsaw strategy promotes positive valence towards mathematics as it creates a positive climate in learning the subject. It implies that the EPTs were able to develop a positive attraction towards the subject as they were able to learn fractions with their peers rather than passively learning from their teacher's lectures. Abed et al. (2020) discovered a similar result where they concluded that learners developed a positive attitude towards the mathematics lessons. As a result, EPTs were more likely to have a strong interest in learning mathematics. The EPTs need to have a high positive attraction towards the subject as they will be the ones paving the way for their students to have more interest in mathematics.

Moreover, the negative attraction and time commitment of the EPTs after the intervention were not statistically different from the pre-intervention. This can be attributed to the stress brought by the new, online setup of education. Though jigsaw strategy proved its efficacy towards the enhancement of mathematics achievement, poor internet connectivity challenges online learning. Thus, affecting the participation of the EPTs in the utilization of the strategy.

Relationship between the Elementary Pre-service Teachers' Interest and Mathematics Achievement

The EPTs who have dedicated more time to solve mathematical problems tend to have low achievement in fractions. This implies that allocating more time to understand the concept of fractions is tiresome, resulting in poor mathematics achievement. This result opposes Spitzer (2021) who found that increasing study time is contributory to success in mathematics.

The result also showed that EPTs who have a higher interest in mathematics tend to have low mathematics achievement. This shows that even though a high level of interest was shown, internal factors such as unpreparedness before taking the test and other personal factors could affect mathematics achievement. The result agrees with Wong and Wong (2019) who showed that those who are inclined to mathematics did not quite see the benefits of learning the subject and vice versa. In contrast, Asbury et al. (2016) and Chen et al. (2018) had proven that a positive outlook towards mathematics has a greater impact in predicting students' achievement in the subject.

The finding indicates that high interest in mathematics does not necessarily guarantee a higher mathematics achievement, which agrees with Pentang et al. (2021) who found that EPTs who are into mathematics did not perform excellently in mathematical problem-solving. This result can help EPTs understand the concept between achievement and interest in mathematics. Hence, they aren't ought to focus on developing the interest of the students towards the subject.

In general, the jigsaw instructional strategy strengthened the mathematics achievement and interest of the EPTs, allowing them to become experts in and develop an interest in fraction operations. Since innovative pedagogies and learning materials enhance the effective transfer of learning (Pentang 2021; Ummah and Hamna 2021), it is suggested that mathematics educators be well-versed in the background and implementation of the jigsaw strategy, particularly in an online setting. Jigsaw strategy is effective despite its application in online classes where the EPTs can have a more meaningful learning experience. Other strategies may be explored to facilitate the training and preparation of the EPTs and to advance their interest and capabilities as future mathematics teachers.

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Modeling students' innovativeness and its factors in learning mathematics amidst COVID-19 pandemic

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ABSTRACT

Innovation allows learners to cope with changes and discover new opportunities. This study aimed to investigate the students' level of innovativeness in learning mathematics amidst the COVID-19 pandemic. A non-probabilistic sampling of 132 students enrolled in Mathematics from Visayas State University were the respondents. Descriptive measures were used to summarize the results, and econometric modeling was constructed to determine significant determinants affecting students' innovativeness. On average, it was found that students considered themselves as "late majority adopters" during the pandemic. This implies that students during the pandemic are considered to have a low level of innovativeness in adopting the new normal activities in distance learning. Result revealed that household assets, monthly household expense, submission of outputs, and health significantly influence students' innovativeness in learning mathematics. Hence, the government must support the students with regard to learning technologies, and teachers should motivate students to adapt to the new setup of classes with an appropriate platform and meaningful activities. Furthermore, the government must prioritize the health of students as they learn during the pandemic.

Keywords: econometric modeling, influencing determinants, level of innovativeness, state university

INTRODUCTION

All sectors in the world, including mathematics education, have been adversely influenced by the effects of the COVID-19 pandemic. In fact, during this unprecedented time, students have difficulty learning mathematics due to some factors including availability of the internet connection (Sabaruddin et al. 2020), accessibility of technological tools (Aguilera-Hermida 2020), and intellectual unpreparedness and self-esteem (Harahap and Fitri 2021), among others. In connection, an in-depth understanding of the life experiences, perceptions, and motivation of students in learning mathematics amidst this crisis cannot be overemphasized. Likewise, Lin et al. (2016) stated that a teacher often has little time to assist individual students, and students often have no one at home to rely on for support. This leads to students' frustration, incomplete assignments, and ensuing poor performances on assessments. Hardship in learning mathematics from home is caused by the lack of learning resources such as not having access to the internet and parents' inability to support their children in the learning process (Putra et al. 2020; ADEC Innovations 2021; Harahap and Fitri 2021).

State universities in the Philippines have been adopting the "new normal" setting since the COVID-19 pandemic started. Collaboration of the global higher education and other societal stakeholders is a need to resolve instructive issues amid the pandemic (Lackie et al. 2020; Waizenegger et al. 2020). It must be the intention of Higher Education Institutions (HEIs) to continue providing quality education. In connection to providing quality education, students must be abreast of the unprecedented times when different learning tools are employed (Cortez 2020). It is worth noting that students' innovativeness plays an important role in affecting students learning mathematics amidst the COVID-19 pandemic. According to Rogers (2002), as cited by Kaminski (2011), innovation is an idea that is perceived as new by individuals. This refers to how individuals adapt to new things which are the basis of their success or failure (Lundblad 2003; Doyle et al. 2014).

Building innovation will reinforce the success in learning mathematics (Suyitno and Suyitno 2018). In that case, there is a need to explore students' innovative values. The level of students' innovation depends on their learning experiences and factors affecting their innovative characteristics. Literature studies revealed that individual innovativeness is influenced by determinants such as demographic profile (Coklar 2012; Ertug and Kaya 2017), learning styles (Incik 2020), learning environment (Konings et al. 2008), e-Learning (Ozcan et al. 2016; Aldahdouh et al. 2020), leisure time (Marques and Biscaia 2019), social relationships (Glinska-Newes et al. 2017) and health aspects (Ikiz and Asici 2017). Hence, the conceptual framework of this study assumes that students' innovativeness is influenced by the mentioned determinants above.

Furthermore, several studies used the Individual Innovativeness Scale (IIS) developed by Hurt et al. (1977) to determine the level of the individuals' innovativeness (Coklar 2012; Ozcan et al. 2016; Parlar and Cansoy 2017; Ali 2019; Incik 2020). Liberna et al. (2021) defined innovativeness in learning mathematics as the adoption of new technologies in accordance with the time being. Moreover, innovation in learning mathematics refers to the new strategies and approaches in solving problems (Hendriana et al. 2019) and it also refers to a creative way of thinking about new ideas (Casinillo et al. 2020). In that case, comprehending the level of students' innovativeness in learning mathematics amidst the pandemic will clarify a deeper intelligence of well-being of students in mathematics education. Therefore, this study is conducted.

Henceforward, the goal of this study was to examine the different determinants that affect students' level of innovativeness in learning mathematics. Precisely, the study sought to answer the following specific objectives: (1) to estimate the level of individual innovativeness in learning; and (2) to construct econometric models and document significant determinants (socio-demographics) that would affect the level of individual innovativeness among students. Results of this study may offer some inputs to educators on strategies and methodologies to maintain a quality teaching-learning process amidst the COVID-19 pandemic.

METHODS

Research Design

The research design of this study is complex correlational that deals with econometric models based on the theory of Individual Innovativeness to address the study's objectives. Primary data were collected on socio-demographic profiles, learning styles, social relationships, health, and individual innovativeness through a developed instrument by Hurt et al. (1977). In describing the data, descriptive measures were used such as percentages, minimum value, maximum value, mean, and standard deviation. For further analysis, ordered logit modeling was constructed to determine the significant factors of students' innovative characteristics in learning mathematics.

Respondents, Ethical Considerations and Research Reflexivity

The respondents of this study were college students enrolled in Mathematics in the Modern World (MMW) during the 2nd semester for the academic year 2020-2021 in Visayas State University (VSU). The survey was made using a Google form and sent via email. The online survey link was posted in the virtual classroom and was forwarded by the faculty to their respective students. In addition, the online survey link was posted on Facebook and the e-learning environment. In this study, a non-probabilistic sampling technique was employed since it applies a non-random method, that is, students who willingly participate in the survey were automatically part of the sample. The survey was open for about three weeks, and a total of 132 out of 564 students responded to the Google form questionnaire. This sample size (132 respondents) is considered large and can suffice to construct econometric models (Jenkins and Quintana-Ascencio 2020). Before the conduct of the survey, a formal letter was sent to the head of the Department of Mathematics and Physics to ask for permission. Before answering the questionnaire, students were informed that the information gathered from them will be treated with high confidentiality in accordance with Data Privacy Act (Republic Act 10173) and their participation was voluntary. In addition, it was explained to students that this study could be used as basis in enhancing their learning style in mathematics. Moreover, the study specifically provides educators with perspectives on how to sustain the needs of students in learning. Despite the influence of COVID-19 to education, flexibility and innovation are essential characteristics students must possess. Likewise, teachers must give quality education and be realistic when they know students' innovative characteristics.

Research Instrument and Data Collection

The questionnaire is composed of the socio-demographic profile, learning styles about flexible learning, school background, and scale of measurement on individual innovativeness in learning mathematics. In the socio-demographic profile, students were asked about the following: age (in years), sex (1=male, 0=female), hometown (1=Urban, 0=Rural), availability of laptop(s) (1=Yes, 0=No), number of hours studying mathematics lessons per week, amount of money spent on internet connection per week (in peso), household size, household assets (in peso), monthly income of the family (in peso), and monthly household expenses (in peso). As to the learning styles about flexible learning, students were asked about the following: preference on learning event (1=asynchronous, 0=synchronous), submission of outputs on-time (1=Yes, 0=No), preferred Learning Modality System (LMS) (1=MOODLE or VSU E-Learning, 0=Other LMS), signal strength using a 10-point Likert scale, 1-Poor, and 10-High, and coping with math anxieties and resiliency using 10-point Likert scale, 1-Slow and 10-Very quick. Table 1 presents the evaluation of the strength of internet connection and coping with math anxiety and resiliency based on the mean perception score.

Table 1. Mean perception score and its over-all rating.

Range of Mean Perception	Over-all rating
1.00–2.80	Very Poor/Very Slow
2.81–4.60	Poor/Slow
4.61–6.40	Satisfactory
6.41–8.20	High/Quick
8.21–10.00	Very High/Very Quick

For other factors in learning mathematics, a 10-point Likert scale was used, 1-Not satisfied at all and 10-Very satisfied. These factors were learning environment, leisure time during the COVID-19 pandemic, social relationships, and health aspects. Table 2 shows the range of mean perception scores and their corresponding description of the different factors in learning mathematics.

Table 2. Mean perception score and its description.

Range of Mean Perception	Description
1.00–2.80	Very Unsatisfied
2.81–4.60	Unsatisfied
4.61–6.40	Neutral
6.41–8.20	Satisfied
8.21–10.00	Very satisfied

Moreover, a measurement on Individual Innovativeness by Hurt et al. (1977) was used to determine the students' innovativeness in learning mathematics. This measurement is composed of 20 statements using a 5-point Likert scale, that is, 1-Strongly Disagree, 2-Disagree, 3-Neutral, 4-Agree, 5-Strongly Agree. The scoring point of Individual Innovativeness is = 42 + (total scores of the 1st, 2nd, 3rd, 5th, 8th, 9th, 11th, 12th, 14th, 16th, 18th, and 19th items) – (total scores of the 4th, 6th, 7th, 10th, 13th, 15th, 17th, and 20th items). For interpretation, the evaluation criteria presented in Table 3 were used.

Table 3. Evaluation criteria of students' level of individual innovativeness.

Range of Scores	Classification
80 and above	Innovators
Between 69 and 80	Early Adopters
Between 57 and 68	Early Majority
Between 46 and 56	Late Majority
46 and below	Laggards/Traditionalists

Data Analysis

For the data analysis, descriptive statistics were employed to summarize the different responses of students such as mean, standard deviation, statistical graphic (pie chart), and Statistical Packages for Social Sciences (SPSS) version 20.0 was used for accurate calculation. Ordered logit modeling was performed to capture the different significant determinants that influence the students' innovativeness during the COVID-19 pandemic. Moreover, some diagnostic tests were employed to ensure a valid inference from the models such as the homoscedasticity test (Breusch-Pagan test), omitted variable test (Ramsey RESET test), multicollinearity test, and normality test for residuals (Shapiro-Wilk test). All calculations in modeling were aided with STATA version 4.0.

RESULTS

Level of Individual Innovativeness

The students' innovativeness mean score measured by the IIS was calculated as 55.46 (± 7.02) which can be interpreted that students were in the category of late majority (Table 3) with regard to learning amidst the pandemic. The majority of the students considered themselves as the late majority (54%) and the early majority (37%). About 3% of them were found to be early adopters. It was also revealed that only 6% of the students found themselves as laggards (Figure 1). Moreover, no student was found to be an innovator.

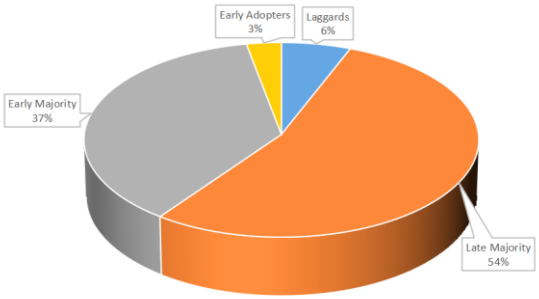

Figure 1. Classification of students' innovativeness.

Determinants of Individual Innovativeness and Econometric Models

The socio-demographic variables of the college students show possible determinants of individual innovativeness (Table 4). The age of the students ranged from 18 to 33 years old (19.89 ± 1.76), and there were 30% (0.30 ± 0.46) male and 70% female. About 70% (0.70 ± 0.50) of students had laptop/s, while 30% did not have. Approximately 27% (0.27 ± 0.44) of the students lived in urban places and 73% lived in rural areas. The number of hours of studying mathematics lessons (per week) ranged from 1 to 60 h, and the amount of money spent on internet connection (per week) ranged from PHP 0 to PHP 1,000. The household size of students ranged from 2 to 12, and their household assets ranged from PHP 2,000 to PHP 4,500,000. On average, students' monthly family income was PHP 18,547.52, and their

monthly household expenses were PHP 11,546.51. More than (0.54 ± 0.50) of students preferred asynchronous classes, while 46% preferred synchronous classes, and 26% (0.26 ± 0.44) usually submitted their outputs on time, while 74% did not usually submit their outputs on time. Students who preferred Modular Object-Oriented Dynamic Learning Environment (MOODLE) as the Learning Modality System (LMS) was 50% (0.50 ± 0.50) and others preferred other LMS. On average, the strength of the internet connection was neutrally satisfactory (5.02 ± 1.73). On average, students could satisfactorily cope with math anxiety (5.20 ± 1.88), and neutrally satisfied in view of their resiliency (5.32 ± 1.75). The students were unsatisfied with the learning environment (4.24 ± 1.69), while they were neutrally satisfied in leisure activities during the COVID-19 pandemic (5.58 ± 2.22). Furthermore, results showed that students were satisfied with their social relationships (6.71 ± 2.12), and they were neutrally satisfied in terms of their respective health (5.16 ± 2.15).

The diagnostic tests implicitly determined whether an econometric model is appropriately specified in regards to the regressors (O'Connell and Liu 2011). Hence, by Breusch-Pagan test, it showed that the variances of the four models had no problem, that is, the models were homoscedastic (Model 1: $\chi^2 = 0.85$, $P = 0.36$; Model 2: $\chi^2 = 2.03$, $P = 0.15$; Model 3: $\chi^2 = 3.57$, $P = 0.06$; Model 4: $\chi^2 = 0.51$, $P = 0.47$). Using the Ramsey RESET test, it revealed that the four models possessed no omitted variable bias, that is, the model did not leave out one or more appropriate variables (Model 1: $F = 0.55$, $P = 0.65$; Model 2: $F = 0.66$, $P = 0.58$; Model 3: $F = 1.23$, $P = 0.30$; Model 4: $F = 1.01$, $P = 0.38$). Regarding the multicollinearity test, the four models had safely ignored a multicollinearity problem using Variance Inflation Factor (VIF), that is, VIF<10. Furthermore, by the Shapiro-Wilk test, the four models had no problem for normality of residuals (Model 1: $Z = -0.13$, $P = 0.55$; Model 2: $Z = 0.61$, $P = 0.27$; Model 3: $Z = -0.784$, $P = 0.78$; Model 4: $Z = 1.39$, $P = 0.08$). Hence, the models were valid for drawing inferences.

Table 4. Descriptive measures for socio-demographic variables of students (n = 132). a-dummy (indicator) variable; b-Philippine Peso (PHP); c-Scale 1 to 10.

Socio-demographic variables	Mean ($\bar{x}$)	Standard deviation (± sd)	Minimum value	Maximum value
Age (in years)	19.89	1.76	18	33
Male[a]	0.30	0.46	0	1
Urban[a]	0.27	0.44	0	1
Availability of laptops(s)[a]	0.70	0.50	0	1
Number of hours studying math lesson (per week)	5.72	7.26	1	60
Amount of money spent on internet connection (per week)[b]	187.71	176.91	0	1000
Household Size	6.10	2.23	2	12
Household Assets[b]	150631.36	535588.50	2000	4500000
Monthly Income of Family[b]	18547.52	26687.46	880	200000
Monthly Household Expenses[b]	11546.51	12254.62	1000	80000
Asynchronous[a]	0.54	0.50	0	1
Submission of Outputs[a]	0.26	0.44	0	1
Modular Object-Oriented Dynamic Learning Environment (MOODLE)[a]	0.50	0.50	0	1
Signal Strength[c]	5.02	1.73	1	10
Coping with Math Anxiety[c]	5.20	1.88	1	10
Coping with Resiliency[c]	5.32	1.75	1	10
Learning Environment[c]	4.24	1.69	1	10
Leisure Time during Covid-19 Pandemic[c]	5.85	2.22	1	10
Social Relationships[c]	6.71	2.12	1	10
Health Aspects[c]	5.16	2.15	1	10

Table 5. Econometric models for students' innovativeness in learning mathematics and its influencing determinants (n = 132). a-dummy (indicator) variable; b-Philippine Peso (PHP); c-Scale 1 to 10. Standard error is enclosed with parenthesis; $*P < 0.10$; $**P < 0.05$; $***P < 0.01$, ns-not significant.

Independent Variables	**Ordered Logit Models**			
	Model I	**Model II**	**Model III**	**Model IV**
Age (in years)				0.0089^{ns} (0.1011)
Urban[a]	-0.4474^{ns} (0.4264)			
Male[a]		0.3188^{ns} (0.4050)		
Availability of laptops(s)[a]		-0.3160^{ns} (0.3985)		
Number of hours studying math lesson (per week)	0.0151^{ns} (0.0241)			
Amount of money spent on internet (per week)[b]			-0.0008^{ns} (0.0011)	
Household Size				0.0883^{ns} (0.0831)
Household Assets[b]	0.4882** (0.2162)	0.5250** (0.2259)	0.5141** (0.2187)	2.64e-07^{ns} (3.64e-07)
Monthly Income of Family[b]			0.0047^{ns} (0.2936)	
Monthly Household Expenses[b]	0.5621** (0.2706)	0.5843** (0.2701)	0.5297* (0.3028)	0.6019** (0.2629)
Asynchronous[a]	0.2320^{ns} (0.3677)		0.2269^{ns} (0.3652)	
Submission of Outputs[a]	0.8852** (0.4357)	0.8160* (0.4489)	0.6281^{ns} (0.4341)	0.9703** (0.4335)
Modular Object-Oriented Dynamic Learning Environment (MOODLE)[a]	-0.2323^{ns} (0.3731)			
Signal Strength[c]		0.0226^{ns} (0.1178)		
Coping with Math Anxiety[c]				0.0727^{ns} (0.1068)
Resiliency[c]			0.1540^{ns} (0.1137)	
Learning Environment[c]				-0.1163^{ns} (0.1241)
Leisure Time during Covid-19 Pandemic[c]		0.0089^{ns} (0.1048)		
Social Relationships[c]				0.0848^{ns} (0.1216)
Health Aspects[c]	0.2888*** (0.0889)	0.2696** (0.1108)	0.2577*** (0.0924)	0.2286** (0.1208)
Chi-squared	28.49	27.87	29.29	23.44
P-value (*P*)	0.0004	0.0005	0.0003	0.0053
Pseudo R-squared	0.1104	0.1080	0.1135	0.0909

The four econometric models have the statistically significant factors to students' innovativeness in learning mathematics (Table 5). Four models were created to make use of all the possible variables affecting students' innovativeness. It is shown that the five models were significant, which implies that there were factors influencing students' innovativeness. However, the four models revealed a small goodness-of-fit (Model 1: Pseudo $R^2 = 0.11$; Model 2: Pseudo $R^2 = 0.11$; Model 3: Pseudo $R^2 = 0.11$; Model 4: Pseudo $R^2 = 0.09$). Thus, there were only a few significant variables that affect innovativeness amidst the pandemic. This implies that students are in the shock of adjusting to the new normal process of distance learning. Model 1 and 2 disclosed that the significant factors influencing students' innovativeness were household assets, monthly household expense, submission of outputs on time, and health aspects. These results were also supported by Model 3. It revealed that household assets, monthly household expenses, and health have influenced the innovativeness of students during the pandemic. Likewise, Model 4 also revealed that

monthly household expenses, submission of outputs on time, and health aspects were significant factors.

DISCUSSION

Level of Individual Innovativeness

Results revealed that, on average, students are considered as a late majority in view of their innovativeness in learning. Hence, these students during the pandemic are resistant to adopting the new normal activities and the use of technology in distance learning. It is concluded that the impact of the COVID-19 pandemic influences the students' anxiety in learning mathematics which results in unproductivity and a low level of innovativeness. Students were cautious about innovations and are reluctant to adopt the use of technology platforms (Doyle et al. 2014). Amidst this COVID-19 pandemic, students felt that they learn better in physical classrooms than through online classes as pointed out in the study of Chakraborty et al. (2021). Likewise, in the study of El Firdoussi et al. (2020), students specified that online learning was not interesting compared to the traditional learning setup. During the pandemic, students are still adjusting to a new setup of classes by creating new routines, trying new activities, and maintaining social connections (Logel et al 2021). In that case, teachers must give some interesting activities with the aid of the advancement of technologies (mathematics software programs) so that students at a distance can develop their innovativeness in learning mathematics.

Determinants of Individual Innovativeness and Econometric Models

The econometric model reveals that household assets, monthly household expenses, submission of outputs, and health of students are the only significant contributors to their innovativeness. It suggests that household assets positively influence the students' innovativeness at their respective homes due to the diverse technology they possess. This result is aligned to Ansong et al. (2015) which revealed that asset possessions impact students' academic achievement. Students with more assets have lots of opportunities to become more creative in learning amidst this pandemic. Likewise, more asset possessions may build their creativity which influences individual innovativeness. Such result is inconsonant with Casinillo et al. (2020) that dealt with a creative learning experience in mathematics. The monthly household expense also has contributed to the students' innovativeness through benefits and comforts of buying goods and services. This means that if the parents of students can afford some tools to aid their education, students have the advantage to deal with distance learning compared to students with low-income families (Melguizo et al. 2016). Casinillo (2019) found that financial problems led to low performance in mathematics. Conclusively, financial stability is very crucial amidst the pandemic. However, the COVID-19 pandemic caused an economic crisis that affected the family income. This means that parents cannot provide some requirements for distance learning which deteriorates students' innovativeness. A financial crisis within households leads to students' declining interest in education.

Moreover, submission of outputs in distant learning influences the innovative skills of students. This suggests that students are eager to finish their given tasks on or before the given deadlines using technology devices during the pandemic. Shuja et al. (2019) found that the usage of devices is good in providing a flexible teaching-learning process and boosts up their assessment outputs on time. The study of Han and Yi (2019) explained that the use of smartphone technology of students positively affects their academic performance. Furthermore, a healthy student is more likely innovative in learning mathematics amidst the pandemic. The study of Jeffries and Salzer (2020) justified that students with health condition results in poor academic achievement and self-efficacy. As explained by Casinillo and Casinillo (2020), health is a predictor of students' motivation in learning. This goes to infer that good health boosts the students' interest and motivates them to do something innovative in the teaching-learning process during distance learning. In addition, students' good health condition goes with the ability to cope with stress in these unprecedented times. On the other hand, results reveal that some demographic profiles such as age, hometown, sex, and household size are independent of the students' innovativeness. Likewise, leisure activities and social relationships do not influence their level of innovativeness amidst pandemic. This is due to the travel restrictions, early curfew, liquor ban, physical distancing, and other restrictions imposed by the national government to combat the spread of the COVID-19. Panarese and Azzarita (2021) divulged that the government restrictions during the pandemic harm the psychological and social well-being of young individuals. Moreover, variables related to distance learning such as availability of laptops, number of hours of studying the subject per week, money spent for the access of internet connection, asynchronous online learning, MOODLE learning environment, signal strength, coping math anxiety, and resiliency are not significant factors of innovativeness.

An unplanned and quick shift to online learning with no sufficient experience resulted in unproductivity and a low level of innovativeness (Li and Lalani 2020). Furthermore, an unconducive place for learning, and without a stable internet connection

led to anxiety and struggle in learning as they participate in their online classes. Similarly, Alvarez (2020) found that distance learning amidst the pandemic was quite challenging not only for internet concern but also for the financial stability of each household that affected and interrupted their learning commitment. On the face of it, teachers must adopt an approach that is suitable for distance learning like giving the students student-friendly learning materials in mathematics with interesting real-life problem examples. In this manner, students who have difficulty in acquiring a good internet connection can also learn despite the challenges brought by the pandemic. According to Khirwadkar et al. (2020), it is necessary to use innovative ideas to evolve teaching strategies in mathematics to maintain a sustainable mathematics education amidst the crisis.

Hence, mathematics teachers are to provide students with necessary and reliable activities amidst the pandemic which will bring them to the adaption of appropriate technology in instruction. This is to prepare them to adapt to changes in instruction and technologies used in their educational endeavors. Teachers must focus on students' creativity that will lead them productive even in their lack of technology resources. Moreover, teachers must provide mathematical activities that are fit for time constraints and feasible during the pandemic. Hence, teachers must not give activities that may jeopardize students' health or may violate some government health protocols during the pandemic. For future research, one may consider the students' happiness or subjective well-being in learning mathematics amidst the pandemic which is a limitation of the current study.

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Pathogen and pesticide contamination in cabbage grown from, Dalaguete, Cebu, Philippines

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ABSTRACT

Food safety is one of the long-sought problems in the world. Chemical and biological characteristics must be considered when evaluating the safety of various food products. This study aimed to assess the food safety of cabbages grown from Mantalongon, Dalaguete, Cebu. Cabbage samples acquired from three different farms in Mantalongon were tested for the presence of *Salmonella* spp. (and other potentially pathogenic bacteria) and pesticide (cypermethrin) residues. To detect the presence of *Salmonella* spp., pre-enrichment and enrichment methods were done. For the analysis of cypermethrin residue, samples were subjected to gas chromatography. No putative *Salmonella* spp. colonies (with a black center) were isolated However, other potentially pathogenic bacteria suspected of *Escherichia coli*, *Enterobacter* sp., or *Shigella* sp. were isolated Cypermethrin concentrations (0.006-0.054 mg kg^{-1}) were within the maximum residue limit. Knowing that some vegetables are eaten raw or slightly cooked, consumers are at risk of ingesting residual amounts of pesticides and are prone to bacterial infection. Hence, the food safety of fresh vegetables should be monitored from local farms to markets.

Keywords: *Brassica oleracea* var. *capitata* L., cypermethrin, food safety, gas chromatography, *Salmonella*

INTRODUCTION

One of the major problems worldwide is food insecurity. Food security is achieved by having enough food accessible and safe food for consumption. Because the world is so preoccupied with problems of the former, the latter is usually disregarded, resulting in the lack of adequate data about monitoring and standards. Another challenge regarding food safety actions is the reactive, rather than preemptive government approach towards food safety issues, such as food poisoning incidences and substandard fresh and processed foods in the market (Collado et al. 2015).

Various parameters are considered when assessing the safety of food produce. They include the monitoring of biological and chemical hazard agents in these foods. The biological aspect refers to the pathogens that contaminate food. The chemical element is about the toxic substances that can cause (acute or chronic) toxicity to the consumers (Singh et al. 2019).

Illnesses caused by pathogen contamination in food items have become significant causes of morbidity and mortality worldwide. In the United States, there are 31 primary foodborne pathogens, but the most significant ones are *Salmonella* nontyphoidal, *Campylobacter*, *Listeria*, and Shiga toxin-producing *Escherichia coli* Castellani and Chalmers 1919 (Adley and Ryan 2016). In fact, in the Philippines alone, the Department of Health (DOH) reported 15,524 nationwide cases of pathogen-caused illnesses from 01 January to 03 June 2017 (DOH 2017). In particular, *Salmonella* spp. have grown so much attention due to its generally high prevalence worldwide and its increased resistance to various antibacterial drugs (Threlfall 2002). These pathogens are mainly acquired from eating raw or improperly cooked meat, egg, chicken, and poultry products (Howard et al. 2012; Bodhidatta et al. 2013). However, meat and poultry products are not the only sources of *Salmonella*; fresh vegetables and herbs, including those of the leafy variety, have also been implicated as vehicles for transmitting microbial foodborne disease worldwide (Aycicek et al. 2006; Beuchat 2006). In addition, there has been an increase in the incidence of *Salmonella* spp. contamination in fresh fruits and vegetables (Quiroz-Santiago et al. 2009; Vital et al. 2014).

In Cebu, Philippines, the major vegetable providers are the farms of Mantalongon in the Municipality of Dalaguete. Their primary vegetable produce includes cabbage, "pechay," and spring onions. Among these vegetables, cabbage is one of the staple ingredients in many Filipino recipes. However, it risks bacterial pathogen contamination such as *Salmonella* spp. due to the poor agricultural practices and unguided post-harvest practices (Liu et al. 2013).

Besides bacterial pathogens, another food safety concern in cultivated cabbages in Cebu is pesticide residues. Mantalongon cabbage farmers depend heavily on pesticides application to protect cabbage against the diamondback moth (Lim 2014). Their most active ingredient is cypermethrin, chlorpyrifos, and spinetoram (Lu 2012). Pesticide application leads to higher yields and better-quality products. Yet, its misuse and misapplication significantly affect the health of the farmers, the people living closer to these farms, and consumers of the contaminated food produce and water due to runoff water containing pesticides. Health records of the municipality indicate an increase in mortality among farmers and an increased number of cases of miscarriages (Lu 2005). These occurrences are symptoms of pesticide poisoning.

According to the local authorities in Mantalongon, Dalaguete, there is no food safety program that monitors the quality of farm-produced vegetables. Furthermore, eating fresh and half-cooked leafy vegetables increased risk of food poisoning associated with the consumption of fresh produce with pesticides and pathogenic bacteria.

This study aimed to assess the safety of cabbage (*Brassica oleracea* var. *capitata* L.) heads grown from Mantalongon, Dalaguete, Cebu. Specifically, it (1) determined the presence of *Salmonella* spp. and other bacteria in cabbages, and (2) determined the cypermethrin residue present in cabbages from the mentioned locality.

METHODS

Sample Collection

Cabbage samples were acquired from three different crop-producing farm barangays of the Municipality of Dalaguete, Cebu, Philippines. Sample one was taken from sitio Alang-alang of barangay Mantalongon. Sample 2 from the same barangay but in another site. Sample 3 was from barangay Tabon beside Mantalongon. The acquisition of samples followed a random opportunistic sampling technique, which depended on which farms were producing cabbage crops during the sampling. Cabbage samples were placed in properly labeled clean plastic bags stored in a cooler with ice (0-4°C) before being transported to the laboratory and immediately analyzed within 24 h.

Isolation and Detection of *Salmonella* spp.

Microbial culture. *Salmonella* spp. were detected on cabbage samples using the method by Andrews et al. (2018). Briefly, 25 g of the cabbage samples were aseptically chopped then weighed It was then mixed with 225 ml 0.5% lactose broth (Sigma-Aldrich, USA) and was incubated at 35°C for 24 ± 2 h for pre-enrichment. From the lactose broth culture, an aliquot of 1 ml was transferred into a 10 ml Rappaport-Vassiliadis (RV) medium (HiMedia, India) for *Salmonella* spp. enrichment. The enrichment cultures, done in duplicates, were then incubated at 42°C for 24 ± 2 h. Aliquots of homogenized samples from the RV medium were serially diluted up to 10^{-8} in peptone water, and the last three dilutions (i.e. 10^{-6}, 10^{-7}, and 10^{-8}) were plated on xylose lysine deoxycholate agar (XLDA, HiMedia, India). These steps were also done in duplicates.

Cypermethrin Residue Analysis

Sample preparation. Traces of cypermethrin residue were detected on cabbage samples using GC-ECD analysis (Calinawan et al. 2016). Fifteen grams of homogenized sample was added with 20 ml of 1% acetic acid in acetonitrile and mechanically shaken for 15 min. QuEChERS extraction salts 6 g $MgSO_4$ (Univar, Australia) and 1.5 g NaOAc (Scharlau, Spain) were added to the mixture, then vigorously shaken by hand for a minute, then another minute by vortex mixer. The sample was centrifuged for 10 min then the supernatant was transferred to a beaker. The extract was concentrated to about 5-7 ml at 45˚C in a water bath. The concentrated extract was transferred to a dispersive solid phase extraction tube containing $MgSO_4$, primary-secondary amine, and C18, then vigorously shaken for 1 min and centrifuged for 10 min. In a water bath, the supernatant was decanted to a beaker and evaporated to dryness at 45˚C in a water bath. The extracted residue was redissolved with 2 ml ethyl acetate then analyzed by gas chromatography with an electron capture detector (GC-ECD).

GC-ECD analysis. The extracts were analyzed for the presence of cypermethrin using GC-ECD. The working condition for the GC-ECD analysis is summarized in Table 1.

RESULTS

Pathogens Isolated from Cabbages

Among the three cabbage samples tested, all of the lactose broth pre-enrichment tubes produced gas

(Table 2), and there were no isolated *Salmonella* colonies with a black center. However, other potentially pathogenic species of bacteria were isolated (Table 3). Certain species isolated had opaque yellow colonies with entire margins (Figure 1A) and translucent red to pink, punctiform colonies (Figure 1B).

Cypermethrin Residue in Cabbages

Cypermethrin residue was detected in the samples from barangay Tabon. The other two samples have residue concentrations below the detection limit of 0.006 mg kg^{-1} (Table 4).

Table 1. Gas chromatography with an electron capture detector.

Instrument	**Perkin Elmer Clarus 500**		
Detector	ECD		
Column	Rtx-CLP, 0.32 μm × 0.32 mm × 30 m		
Oven Temperature	Rate, °C min^{-1}	Initial temperature, °C	Hold, min
	-	230	3
	15	290	5
Carrier gas	Nitrogen, UHP		
Column flow rate	2.5 ml min^{-1}		
Injection volume	1 μl		

Table 2. Growth and gas production of pre-enriched endogenous bacteria from the sampled cabbages. Coliforms such as *E. coli* produce gas in lactose broth tubes while Salmonella does not.

Sample	**Sample Source**	**Growth (Turbidity)**	**Gas Production**
1	Sitio Alang-alang, Mantalongon, Dalaguete, Cebu	✓	✓
2	Sitio Private, Mantalongon, Dalaguete, Cebu	✓	✓
3	Barangay Tabon, Dalaguete, Cebu	✓	✓

Table 3. Number of putative *Salmonella* colonies with black center and other potentially pathogenic bacteria isolated from the three cabbage samples.

Sample	**Sample Source**	***Salmonella* sp.**	**Yellow Colonies**	**Red/Pink Colonies**
1	Sitio Alang-alang, Mantalongon, Dalaguete, Cebu	0	✓	✓
2	Sitio Private, Mantalongon, Dalaguete, Cebu	0	✓	✓
3	Barangay Tabon, Dalaguete, Cebu	0	✓	✓

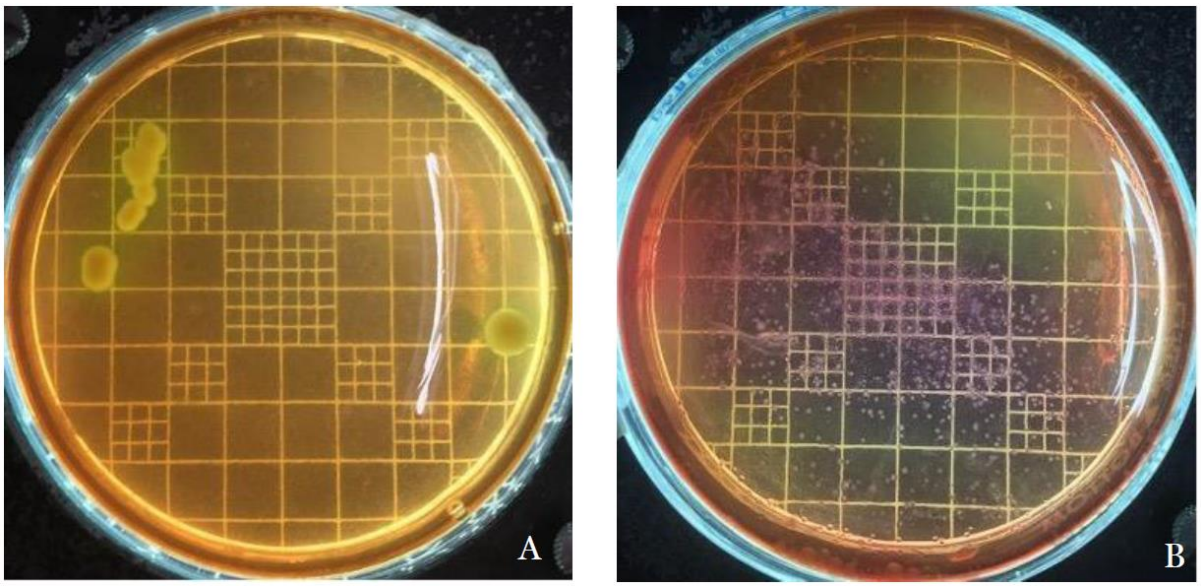

Figure 1. (A) Opaque yellow colonies with entire margin. (B) Translucent red to pink colonies with punctiform shape.

Table 4. Concentration of cypermethrin residue in the three cabbage samples compared to allowable limit based on the studies by Zhang et al. 2007 and Akomea-Frempong et al. 2017.

Sample	Sample Source	α-Cypermethrin, mg kg^{-1}	Allowable Limit, mg kg^{-1}
1	Sitio Alang-alang, Mantalongon, Dalaguete, Cebu	< 0.006	1
2	Sitio Private, Mantalongon, Dalaguete, Cebu	< 0.006	
3	Barangay Tabon, Dalaguete, Cebu	0.054	

DISCUSSION

Presence of Bacteria in Cabbages

Kim et al. (2022) explained that *Salmonella* spp. is a prominent foodborne pathogen that poses a health risk to the general public. *Salmonella* is responsible for over 450 deaths and 1.2 million illnesses each year. Hence, the absence of putative *Salmonella* spp. in the cabbage samples is ideal because the acceptable *Salmonella* spp. content in any food samples is zero (Table 5). The sources of pathogenic bacteria are usually from eggs, dairy products, and meats (Crum-Cianflone 2008). Thus, its absence in leafy vegetables is unusual. Also, Patel and Sharma (2010) reported that the attachment strength of *Salmonella* was significantly lower on cabbage compared to Romain lettuce and other leafy vegetables. Kuan et al. (2017) did not detect *Salmonella* spp. in cabbages from Kuala Lumpur, Selangor, and Putrajaya.

Conversely, Odu and Okomuda (2013) and Saw et al. (2020) found 42.9% and 3.3% of their cabbage samples, respectively. Such differences in detecting foodborne pathogens are common as they arise during pre- and post-harvest handling, especially in hygienic and agricultural practices.

Isolated yellow colonies are suspected to be under the genera of *Enterobacter* and *Escherichia* (HiMedia Laboratories 2015). Some *Enterobacter* spp., like *E. cloacae* and *E. aerogenes* Hormaeche and Edwards, 1960, are normal microflora in the intestinal tracts of humans and animals (Davin-Regli and Pagès 2015). Members of genus *Escherichia*, like *E. coli*, are likewise normal microflora in the guts of humans and animals. The presence of normal intestinal flora in the food samples indicates fecal contamination in the farm. Fecal contamination in the sampled farms is highly possible because many farmers use animal manure as organic fertilizer due to its availability, inexpensiveness, and relative safety instead of chemical fertilizers.

Despite being normal intestinal flora in human guts, bacteria can cause infections due to their opportunistic characteristic. *Escherichia coli* and *Enterobacter* are mainly normal flora of the large and small intestines, respectively. However, they go into the stomach when ingested, damaging the stomach lining, leading to diarrhea and vomiting (Evans and Evans 1996).

Isolated red or pink colonies are suspected of *Shigella* spp. or other *Salmonella* spp. or strains that do not form black-centered colonies (ISO 21567 2004; HiMedia Laboratories 2015). They are ubiquitous pathogens that are common contaminants of raw vegetables. Members of the genus *Shigella* are the leading cause of shigellosis or traveler's diarrhea, wherein it is transmitted through ingestion—usually through fecal-oral contamination from previously infected organisms (Hale and Keusch 1996). They typically thrive in areas where there is poor sanitation. Therefore, if the species isolated are indeed *Shigella* spp., then the bacterial load (in CFU g^{-1}) must be determined to assess whether the sampled farms need improvements in sanitation.

Table 5. Acceptable amount of *Salmonella* spp. in food from various countries.

Acceptable amount of *Salmonella* spp.	Country	Sources
0	China	National Health and Family Planning Commission of People's Republic of China (2013)
0	Ireland	Institute of Medicine and National Research Council (2003)
0	Australia	
0	New Zealand	
0	Canada	

Salmonella spp. that do not form black-centered colonies and only form translucent red colonies are *S. enterica* Le Minor and Popoff 1987. However, these serovars only constitute the minority of the entire genus (ISO 6579 2002), which means that the probability of the isolated species being *Salmonella* is less likely.

The putative identities of the isolated bacteria are *E. coli*, *Enterobacter* sp., or *Shigella* sp. The presence of *E. coli* or *Enterobacter* sp. indicates fecal contamination since both of these bacteria are normal intestinal microflora of many animals. The use of animal manure as organic fertilizer can cause such contamination. On the other hand, *Shigella* spp. are ubiquitous pathogens that commonly contaminate raw vegetables (Hale and Keusch 1996). They thrive in areas with low sanitation; thus, their presence suggests improving the farms' sanitation practices.

Cypermethrin Residue in Cabbages

The persistence of cypermethrin residues in cabbages could be due to several reasons. One of the reasons could be farmers' negligence in withholding time after pesticide application. A pesticide's withholding period is the time that must elapse between its last application and the day of the harvest. Farmers disregard withholding time to meet the high market demands for crops, overcome the unpredictable unseasonal storms, and compensate for a daily source of income. However, farmers must be educated and ensure strict adherence to pesticide withholding time to yield lower or no pesticide residues in cultivated produce from the surveyed area.

Another contributing factor to the persistence of cypermethrin residue is the excessive amounts of pesticides used Calinawan et al. (2017) reported that most farmers in the study sites have no training about the pesticides' recommended doses and spray intervals. They mostly base these decisions on their experience as to which amount they perceive is most effective. They only consulted pesticide dealers for the recommendation of pesticide use, but only a few were found abiding by the advice of agriculture experts. Based on personal communication with the farmers, pesticide contamination of cabbages is expected to happen more frequently over the succeeding years due to excessive use of pesticides.

The detected residue in Sample 3 (0.054 mg kg^{-1}) was within the allowable cypermethrin concentration limit of 1 mg kg^{-1} for cabbages (Zhang et al. 2007; Akomea-Frempong et al. 2017). Such low concentration could be attributed to the current farming practices. Lim (2014) reported that Mantalongon farmers planted odorous flowers that naturally repel cabbage pests. The farmers also planted "trap crops," which are weeds that the diamondback moths prefer over cabbages. Some farmers also developed a natural pesticide made from "tubli" vine (*Derris elliptica* (Wall.) Benth 1860) to kill cabbage insect pests. The presence of wasps on the farm also helps control cabbage insect pests. Calinawan et al. (2016) also detected low cypermethrin residue values in Mantalongon cabbages. They explained that the low concentration of pesticide residue could be due to weather conditions and the frequency of pesticide application. Rainfall can disperse the pesticide residue to other areas, wash out the pesticide from the cabbage leaves, and leach the pesticide from the vegetable to the soil.

Currently, no existing norms for pesticides in the Philippines are established Thus, other international guidelines, such as the Maximum Residue Limit issued by the European Commission (2022), were used for comparison. Even though the cypermethrin levels are within the permissible limit, this study proves that pesticides residues persist in post-harvest cabbage heads. Following previous reports (Lim 2014; Calinawan et al. 2016; Nisha et al. 2021), routine testing of active substances, additives, and pesticide carrier materials could be done in the future to assure food safety. Adopting appropriate agricultural practices and quality control techniques as tactics for producing safe food can help to reduce health risks for consumers. It is also good to conduct extensive pesticide monitoring on environmental samples in the area. This will make implementing an effective risk assessment strategy easier to guide suitable interventions.

In conclusion, cabbages grown from Mantalongon and Tabon, Dalaguete, supplied to most places of Cebu and some neighboring provinces are contaminated with potentially pathogenic bacteria. While the pesticide residue levels in cabbage are within acceptable limits. This observation suggests that food safety assessments must be done regularly to create a more systematic approach in preventing biological and chemical contaminations of fresh produce. In future investigations, it is recommended to collect more samples from other farms in Dalaguete to reflect a larger sample size and reach a more thorough conclusion. A periodic examination of the produce is also recommended (e.g. quarterly in a year) to evaluate the quality of the cabbages produced The local government can initiate regular education and integrated pest management training programs for farmers on proper and safe pesticide use. Training and education on proper hygienic handling, transportation and storage of vegetables can also be extended to develop a hygienic management guide to monitor and assess bacterial pathogen contamination in fresh vegetables from farm to market place and to avoid bacteriological food spoilage and contamination that can lead to related health issues.

Furthermore, biochemical and molecular testing is also recommended to confirm the identity of the

bacterial isolates. Confirmation of the identities of the bacterial isolates can help in the decision-making process to determine which aspects of food safety and quality assurance can be improved Lastly, this study is a fundamental guide for future food safety studies on cultivated food produce such as cabbage to set maximum residue limits for biological and chemical hazards in food in the Philippines as food safety standards.

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***ROLE OF AUTHORS**: CAM – conceptualized the study, designed the experiment, analyzed the data, wrote the research paper; KJCB – assisted in analyzing the data and writing the paper.*

Laboratory investigation on the moisture susceptibility and fatigue resistance of hot mix asphalt modified with high- and low-density polyethylene plastic wastes

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ABSTRACT

The demand for better management of plastic wastes all over the world is increasing. Polymers such as high-density polyethylene (HDPE) and low-density polyethylene (LDPE) are examples of these wastes. Studies showed that these could be used as polymer modifiers that could improve asphalt pavement performance. Although several studies had been conducted to evaluate the performance of asphalt mixtures with HDPE and LDPE, conflicting results had been seen. Additional research is still needed to find out the true effect of plastic on the performance of asphalt mixtures. Hence, this study assessed the performance of hot mix asphalt (HMA) modified with HDPE and LDPE pellets. The Marshall mix design was used to prepare, evaluate HMA mixtures and determine the optimum percentage of HDPE and LDPE that can be added to HMA. Moreover, wheel-tracking, and immersion-compression tests were used to evaluate rutting resistance and compressive strength of HMA mixtures, respectively. Results showed that the addition of 8% HDPE and 8% LDPE by weight of bitumen are the optimum contents. The performance of the HMA mixtures with HDPE and LDPE in terms of fatigue resistance and moisture susceptibility shows improved results. This proves the potential use of the materials as polymer modifiers in HMA. Moreover, HMA with HDPE when compared to the HMA with LDPE shows better results in reducing the moisture susceptibility and improving the fatigue resistance of HMA.

Keywords: Marshall stability, optimum binder content, plastic wastes, polymer modified HMA

INTRODUCTION

The production of waste such as plastics is increasing with the growing population. Countries have been facing solid waste management problems. Recycling plastic wastes as modifiers of materials for the construction of roads and infrastructure is gaining acceptance worldwide (e.g. Akinpelu et al. 2013; Arabani et al. 2017; Brasileiro et al. 2019). This is not only due to economic reasons, but also a way to put wastes into something useful. In the Philippines, the Department of Environment and Natural Resources (DENR) recorded those residential wastes which include plastic wastes constitutes 56.7% of the municipal solid waste (MSW) generation in the Philippines. Recyclable wastes account for almost a third of MSW with plastics comprising around 38% of these (DENR 2018). Hence, there is a need to make use of these wastes so that disposal to landfill sites are minimized if not abolished.

Flexible pavements are often used for the construction of roads in various countries like the Philippines. They need to improve their quality and performance considering the increasing traffic volume on roads. One way to improve the properties and quality of asphalt pavement is the addition of polymers such as plastic wastes. Polymers help improve binder properties resulting in safer roads and reduction of maintenance (e.g. Costa et al. 2013; Abdullah et al. 2017; Deshmukh et al. 2017). The addition of plastic wastes to asphalt mixture likely increases its stiffness, viscosity, strength, rutting resistance and fatigue resistance (e.g. Sutradhar et al. 2015; Manju et al. 2017; Sarkar 2019; Wu and Montalvo 2021). However, some results show negative effects to other performance parameters of asphalt mixtures (Wu and Montalvo 2021).

Various studies that investigated the effects of the modification of hot mix asphalt (HMA) with plastic wastes such as high-density polyethylene (HDPE) or low-density polyethylene (LDPE) also vary in the results of optimum plastic content. For example, Nejad et al. (2014) after investigating the performance of HMA with HDPE found out that mixtures with HDPE exhibited higher fatigue life compared to the control. Additionally, results also showed better rutting resistance for HDPE-modified mixtures. In other studies, the percentages of plastic wastes added in the modified asphalt mix range from 2% to 20% (e.g. Kofteci 2016; Abdullah et al. 2017; Dalen et al. 2017; Chegenizadeh et al. 2021) and the most common concentration of plastic waste for the modified asphalt mix was 10% by weight of the binder (e.g. Rahman et al. 2013; Chandrawal et al. 2016; Asare et al. 2019).

Studies indicate that the number of plastic wastes to be added to the HMA mixture depends on the area where the materials must be applied, its size, type of plastic wastes, type of mineral filler, among other factors (Dalhat and Wahhab 2017; Abu Abdo and Khater 2018; Khurshid et al. 2019). The aggregates and bitumen used in each study were available locally in their countries. In previous studies, different types of bitumen were used such as AC 35/50, 40/50, 60/70, and 70/80, 80/100 (e.g. Attaelmanan et al. 2011; Jain et al. 2011; Nasir et al. 2014; Sojobi et al. 2016). In some of the studies, performance of the mix has shown conflicting results. For example, HDPE improve and worsen rutting resistance (Wu and Montalvo 2021). Also, polyethylene terephthalate (PET) led to a worsened moisture resistance and thermal cracking resistance. These conflicting results indicate that additional research is necessary to further investigate the true effect of the addition of plastics on the performance of the asphalt binder and asphalt mixtures (Wu and Montalvo 2021).

With the demand for utilization of plastic wastes to road construction in the Philippines, this study aimed to identify the optimum content of HDPE and LDPE that could be applied in this context. Specifically, this study evaluated the volumetric properties and the effect of the concentration of HDPE and LDPE on the properties of HMA such as fatigue resistance and moisture damage resistance.

METHODS

Materials

Asphalt cement (AC) penetration grade 60/70 was used (Table 1). Aggregates of Grading D according to the DPWH (2017) standards (Table 2) were utilized. Cement was used as a mineral filler for HMA. Pelletized recycled HDPE and LDPE was used with a diameter of not more than 4.75 mm. The percentage of recycled HDPE and LDPE plastic served as an additive to the bitumen of the asphalt mixture with 8%, 10%, and 12% by weight of bitumen.

Table 1. Table 1. Properties of asphalt cement 60/70 asphalt binder utilized for control and polymer modified hot mix asphalt.

Property	Standard
Penetration, 25°C; 100 g, 5 s, 0.1 min	60–77
Softening point, °C	48–53
Flash point	Min 200
Ductility, cm	Min 100
Mass	Min 0.1
Decreasing Mass, %	Max 1.0

Table 2. Table 2. Details of grading D aggregates used in producing hot asphalt mixtures based on Department of Public Works and Highways (2017).

Sieve Size (mm)	% Passing	Grading	% Retained	Weight of Aggregate (g)	Cumulative (g)
9	100	100	-	-	-
12.5	95–100	97	3	36	36
9.5	74–92	83	14	168	204
#4 (4.75)	48–70	59	24	288	492
#8 (2.36)	33–53	43	16	192	684
#16 (1.18)	22–40	31	12	144	828
#30 (0.60)	15–30	23	8	96	924
#50 (0.30)	10–20	15	8	96	1020
#200 (0.075)	4–9	7	8	96	1116
Mineral Filler	7	-	-	84	1200

Mix Design, Stability, and Flow

The Marshall Mix Design method according to the American Society for Testing and Materials (ASTM) D1559 (ASTM 2020) was used in designing the HMA mix and analyzing the optimum content of bitumen and plastic wastes. First, samples were prepared to determine the optimum binder content. With air voids designed between 3–4%, the determined optimum binder content is 5.5%. Then for testing the volumetric properties of HMA, three samples each were prepared for the control mix, and samples with 8%, 10%, and 12% HDPE and LDPE, separately.

The HDPE and LDPE modified HMA consists of recycled HDPE and LDPE plastic, bitumen, aggregate, and filler. Aggregates were batched, then heated in the oven at 200ºC for 24 h. Then bitumen was heated in an oven at a temperature of 180ºC for 1 h, then mixed with the aggregates at a temperature of 170ºC–180ºC. The mixture was poured and compacted at 75 blows on each side in a standard specimen mold. After compaction was completed, the sample specimen was removed from the mold and undergone a cooling process for at least 24 h. Specimens were placed in a water bath at 60ºC for 30 min before testing.

The Marshall stability and flow test indicate the performance measure for the Marshall mix design method. Marshall stability is the maximum load that a compacted specimen may carry at 60ºC. Stability is equal to the maximum load in kilogram. Flow value is the total deformation the Marshall test specimen undergoes at the maximum load. The criterion for the test is heavy traffic with property standards (Table 3).

Table 3. Marshall mix design criteria used for evaluating hot mix asphalt performance test results.

Experiment	Min	Max
Bulk Specific Gravity (G_{mb})	2.20	2.50
Maximum Theoretical Density (G_{mm})	2.40	2.70
Air Voids (%)	3.00	5.00
Marshall Stability Adjusted (N)	8,006	-
Marshall Flow Adjusted (0.25 mm)	8	14

The formulas indicated below were used to calculate the G_{mm}, $G_{mb,}$ and air voids. Equation 1 shows the formula for determining the G_{mm}, where G_{mm} is the maximum theoretical density, A is the mass of the dry sample, D is the calibrated mass of the container and water, and E is the mass of the vacuum.

$$G_{mm} = \frac{A}{A + D - E} \qquad \text{Eq. 1}$$

Equation 2 shows the formula for determining the G_{mb}, where A is the mass of the dry sample, W is the mass of the sample on immersion, and SSD is the mass of the sample after immersion.

$$G_{mb} = \frac{A}{SSD - W} \qquad \text{Eq. 2}$$

The percent air voids are presented in equation 3, where both the G_{mm}, G_{mb} calculated using the results from equations 1 and 2.

$$\%\ air\ voids = \frac{G_{mm} - G_{mb}}{G_{mm}}\ x\ 100 \qquad \text{Eq. 3}$$

The Marshall Stability is calculated using equation 4, where R is the reading on martial test equipment, CR is the calibration factor on the equipment which is 30.34 pounds/division in this case. R should be in the range of 3.0 - 4.5 mm to pass.

$$Stability = (R\ x\ CR) \qquad \text{Eq. 4}$$

After these tests, the modified bituminous mixtures were prepared for testing the fatigue and moisture damage resistance of the HMA control mix and the modified ones.

Fatigue Resistance Test

The HMA resistance to fatigue is one of the crucial parameters of an asphalt pavement. The Hamburg wheel track test according to the American Association of State Highway and Transportation Officials (AASHTO) T324 (AASHTO 2020) was used to test properties of HMA through a wheel that gives repeated loads to the asphalt specimen. The performance of the asphalt mix samples is related to actual performance in the field. Fifteen samples were prepared for testing the fatigue resistance of HMA with and without the plastic wastes. The test was run for approximately 2 h. After the test, the deformation of the samples was measured. The deformation is obtained by getting the height difference of the original height and middle part of the specimen which was subjected to repeated loading.

Moisture Damage Resistance Test

Moisture induced damage is a complicated mode of distress leading to the loss of stiffness and structural strength in asphalt pavement mixture. This will also cause a financial burden in maintaining the

pavement structure. The immersion-compression test was conducted to measure the loss of asphalt strength due to water on compacted bituminous mixtures. In conducting this test, samples were grouped into wet and dry conditions. Eighteen samples were prepared for testing the moisture damage resistance. The standard specimen in this test has a diameter and height of 101.6 mm. This test aims to obtain the first appearance of IRS, including full meaning as index of retained strength calculated as shown in equation 5, where S_1 is the compressive strength of unconditioned specimens, and S_2 is the compressive strength of conditioned specimens. The value of the IRS should be greater than 70% to be able to pass this test.

$$IRS, \% = \frac{S_2}{S_1}\ x\ 100\% \qquad \text{Eq. 5}$$

Statistical Analysis

The analysis of variance (ANOVA) was utilized in this study to identify if there is a statistical significance between the means of the HMA without HDPE and LDPE and the ones with the percentage of these waste plastics. The principle is that the total variation in the dependent variable is broken into one, and is related to some specific causes, known as the variation between the samples (Molugaram and Rao 2017). Variations within the samples are attributed to chance. The null hypothesis states that there is no significant difference between the groups. The alternative hypothesis states that there is a significant difference between the means and groups. This further shows that at least one of the means differ from the others.

RESULTS

HMA Volumetric Properties

Bulk specific gravity *(G_{mb})* and maximum theoretical density (*G_{mm})* were obtained and were used in calculating the percent air voids in the mix. G_{mm} is always greater than G_{mb}. The values of G_{mm} for all samples tested (Table 4) are all within the range according to DPWH standards of 2.4–2.7. While the values of G_{mb} were all within the range of 2.2–2.5 according to DPWH standards (Table 3). HMA with HDPE had lower G_{mb} and G_{mm} compared to those with LDPE. Statistical analysis showed that there is no significant difference between these values compared to the control HMA. This result means that the HMA with plastic wastes can be used as a substitute for conventional HMA.

The values obtained for air voids (Figure 1) were within the parameters of the standard test values given by the DPWH as seen in Table 3 (within 3–5%). In general, HMA with LDPE and HDPE has lower air voids compared to the control mix (4.03%). With increasing HDPE and LDPE content, the percentage of air voids increases as well. HMA with 8% HDPE has the lowest value of air voids (3.21%) compared to the control mix and HMA with 8%, 10%, and 12% HDPE and LDPE. HMA with 12% LDPE plastic showed no difference compared to the controlled mix, which means the addition of 12% LDPE plastic in HMA did not lessen the small airspaces that occurred in the HMA.

Table 4. Average bulk specific gravity and maximum theoretical density of hot mix asphalt samples prepared for performance testing. HMA – hot mix asphalt; HDPE – high-density polyethylene; LDPE – low-density polyethylene.

Property	HMA control	HMA with 8%		HMA with 10%		HMA with 12%	
		HDPE	LDPE	HDPE	LDPE	HDPE	LDPE
Maximum G_{mm}	2.606	2.579	2.606	2.582	2.586	2.59	2.599
G_{mb}	2.501	2.494	2.503	2.493	2.497	2.487	2.487

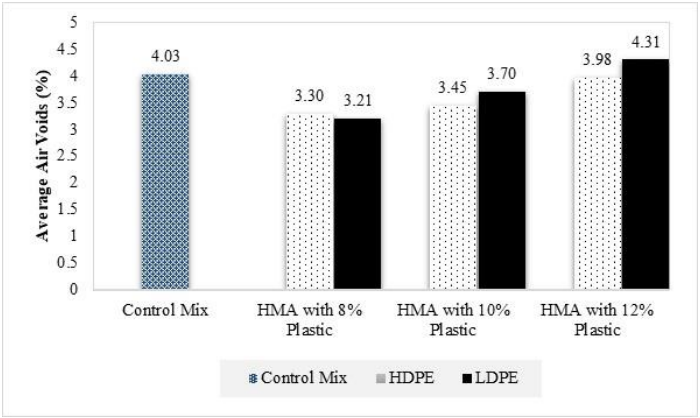

Figure 1. Average values of percent air voids for hot mix asphalt mixtures with and without plastic content.

Marshall Stability and Flow

The results for Marshall stability (Figure 2) passed the minimum stability required of 8,006 N. This is according to the DPWH standards (Table 4). The stability of samples with 8% and 10% HDPE and LDPE plastic wastes surpasses the performance of the controlled mix by 358–1660 N. While HMA with 12% HDPE and LDPE had stability value lower than the control mix by 417–254 N. HMA with 8% LDPE plastic wastes gave the highest stability value. This means that it can resist more horizontal deformation when subjected to severe traffic loads.

The addition of 8%, 10%, and 12% of HDPE plastic wastes in HMA (Figure 3) have passed the standard maximum value for Marshall flow in Table 4. HMA with 8% and 10% HDPE showed the same flow value which is lower than the control. However, a higher flow value compared to the control was exhibited by HMA with 12% HDPE. While the addition of 8% LDPE had the same flow value as that of the control mix. While HMA with 10% HDPE had a lower flow value than the control. A higher value of flow was also exhibited by samples with 12% LDPE plastic wastes. Improvement of flow value compared to the control was observed within 8% and 10% contents. However, a further increase in the plastic content increased the flow value.

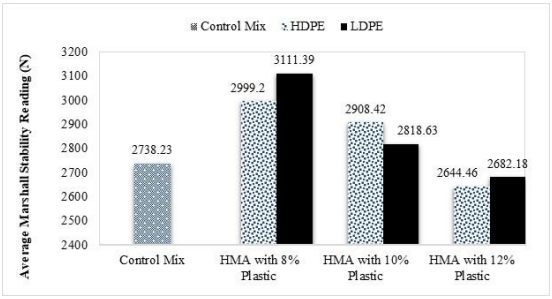

Figure 2. Average Marshall stability of hot mix asphalt control and modified mix.

Based on the statistical analysis results for stability and flow, there was no significant difference between the control mix and the mixtures modified with HDPE and LDPE. This means that the addition of plastic is at par with the results of the mix without plastic waste. However, there was no significant improvement in the stability and flow results.

HMA Fatigue Resistance

Results of the fatigue resistance test (Figure 4) showed that the samples with HDPE and LDPE deformed were lesser than the control HMA by 2.67 mm, 0.67 mm, and 1 mm. Having high concentration percentages of HDPE and LDPE gives lesser deformation which indicates that these helps increase the useful service life of the pavement. However, statistical analysis showed that adding LDPE plastic waste had no significant effect on improving the deformation of HMA. While adding HDPE plastic waste on HMA had a significant effect as the *P*-value is lower than the significance level.

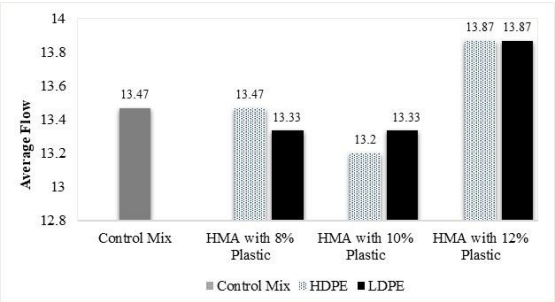

Figure 3. Average values of Marshall flow of hot mix asphalt control and modified mix.

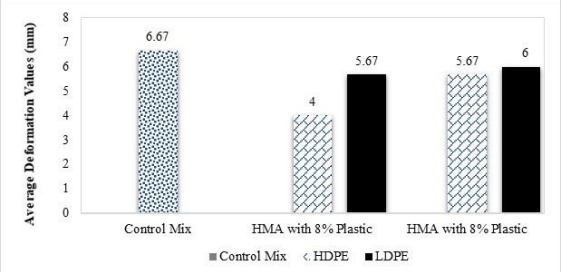

Figure 4. Deformation of hot mix asphalt with and without plastic wastes.

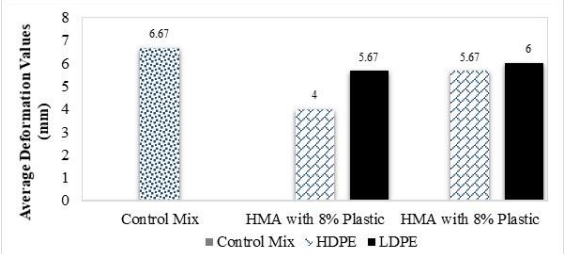

Figure 4. Deformation of hot mix asphalt with and without plastic wastes.

The relationship between the deformation and the additional percentages of HDPE and LDPE plastic wastes is shown in Figure 5. As the additive percentages of HDPE and LDPE in HMA increases, the deformation also increases. Thus, an additional 8% and 10% of HDPE and LDPE plastic wastes in HMA did not surpass the deformation of conventional HMA.

Statistical analysis showed that the addition of HDPE and LDPE might not improve the fatigue resistance but could be used instead of the conventional HMA. This implies the potential use of the plastics instead of being put to waste.

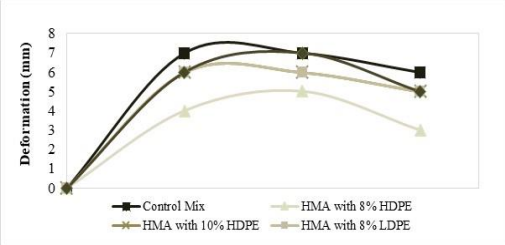

Figure 5. Trends of deformation in hot mix asphalt with and without high-density polyethylene and low-density polyethylene.

HMA Moisture Damage Resistance

Both the average dry HMA sample specimen containing 8% HDPE and LDPE did not perform well compared to the control mix when it comes to the compressive strength (Figure 6). While both averages of wet HMA sample specimen containing 8% HDPE and LDPE performed well as it showed higher compressive strength than the control mix. Statistical analysis indicated a significant effect on both the addition of HDPE and LDPE on the compressive strength of a dry HMA, while wet HMA containing HDPE and LDPE showed no significant effect on the compressive strength of HMA.

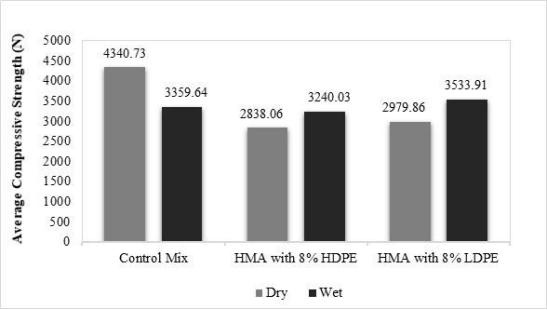

Figure 6. Average compressive strength of hot mix asphalt mixtures with and without plastic content.

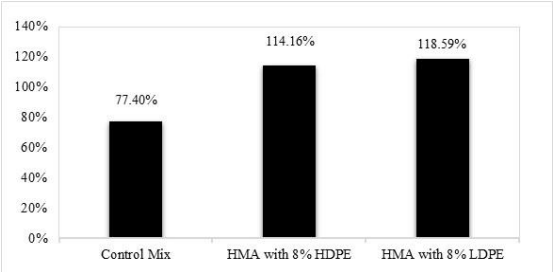

Figure 7. Percent index of retained strength of hot mix asphalt samples with and without high-density polyethylene and low-density polyethylene.

The values obtained have passed the minimum IRS value which is 70% (Figure 7). Both the addition of HDPE and LDPE to HMA helped improve moisture damage resistance of HMA with higher IRS compared to the control mix. IRS of the HMA sample specimen with 8% HDPE plastic wastes had a greater resistance to moisture damage compared to the control mix by 36.76%. While the IRS of the HMA sample specimen with 8% LDPE has a higher resistance to moisture damage compared to the control mix by 41.19%.

DISCUSSION

The volumetric properties of HMA first investigated include the bulk specific gravity, maximum theoretical density, percentage of air voids, Marshall stability, and flow. Using AC 60/70 and aggregates of grading D, tests were done to determine the optimum concentration of HDPE and LDPE that could be added to HMA. Also, fatigue resistance and moisture damage resistance of HMA mixture were evaluated.

Volumetric Properties, Stability and Flow

Results of tests performed showed that volumetric properties of HMA with HDPE and LDPE have passed all the DPWH standards in terms of Marshall stability, flow, and air voids. These results were compared to the HMA control mix. Further, HMA with recycled HDPE plastic has lower percentages of air voids compared to HMA with recycled LDPE plastic. Higher percentages of air voids mean that the sample absorbed more water and air that may result in cracking and stripping of the asphalt.

HMA Fatigue Resistance

HMA with 8% LDPE can resist more horizontal deformation and can increase the fatigue resistance by 13.63%. In HMA, having a high and good Marshall stability means resistance to horizontal deformation and an increase in fatigue resistance. HMA with 10% HDPE reduces permanent deformation by 1.98%. Low vertical deformation as indicated by the flow value, showed that the sample can resist more permanent deformation. HMA with the addition of 8% HDPE reduces permanent deformation by 40.03%. Low vertical deformation indicates that the sample can resist more permanent deformation and can increase the fatigue resistance of HMA. This is supported by Chegenizadeh et al. (2021) that the mixtures containing 8% HDPE is best in rutting resistance performance. Although stone mastic asphalt (SMA) mixtures with 4% HDPE was in this study, it shows the best fatigue resistance.

HMA Moisture Damage Resistance

HMA with 8% HDPE and LDPE plastic wastes both exceeded the standard IRS value of 70% and that of the control mix. Having a high IRS value

indicates that a sample is less susceptible to moisture. HMA with 8% LDPE plastic waste can resist more stripping damage by 53.22%. This result is quite like results in the previous study (e.g. Haider et al. 2020a,b) where compacted asphalt mixtures with various types of aggregates was used and was found that mixtures with waste plastic modifiers of 9% HDPE and LDPE have better moisture resistance than normal asphalt mixture without modifiers.

Test results in this study show that HMA with a concentration of 8% HDPE and LDPE plastic waste is the recommended optimum plastic content that can potentially improve the performance of HMA. These results support past studies where researchers found the optimum contents of plastic wastes to be between 5–10% (e.g. Jain et al. 2016; Al-Hadidy 2019; Asare et al. 2019; Haider et al. 2020a,b; Chegenizadeh et al. 2021). However, results here are different from that of other studies such as that of Jain et al. (2011) who recommended 15% of plastic wastes to be added. The difference may be due to the method of adding the plastic particles to the aggregates as contrary to addition to the binder as utilized in this study. Also, Kofteci (2016) found that 2–4% of HDPE by weight of bitumen in HMA leads to best resistance to moisture damage. Moreover, findings in this study also show that HMA with HDPE is more effective than the HMA with LDPE in terms of reducing the moisture susceptibility and improving the fatigue resistance of HMA.

These results can be helpful to local authorities in the Philippines. HDPE and LDPE plastic wastes with the proposed percentage of 8% can be used for the improvement of road performance in the country. Constructing field test road sections based on the findings in this study can help further evaluate HMA performance in the field. However, this study is not free from limitations and imperfections. Additional research can be done to assess the effect of HDPE addition to the resistance of HMA to cracking, rutting, and fatigue at different mix temperatures. Further investigation is also recommended incorporating a combination of HDPE and LDPE percentage in HMA using various aggregate grading and AC contents. This may lead to determining the lowest mix temperature possible for HMA which can potentially reduce operating costs in producing asphalt mixtures. Additional additives may also be needed for lowering mix temperatures.

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Determinants of evacuation decision of households at Maypangdan, Borongan City, Eastern Samar, Philippines: A case of Typhoon Hagupit

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ABSTRACT

The Philippines is frequently visited by strong and destructive typhoons, claiming hundreds of lives and extensive damage to the environment, and properties. To minimize negative impacts, understanding evacuee behavior for evacuation planning is essential. Determinants of household evacuation decision were investigated in this study using 164 valid observations obtained through face-to-face interviews with household heads in the affected area of Typhoon Hagupit in Barangay Maypangdan, Borongan City, Eastern Samar, Philippines. Correlation analysis and logistic regression were used to identify significant factors that affect household evacuation decisions. Results showed that the presence of children less than 10 years of age and elderly, house material, and house floor level affect the household evacuation decision. The insights from the results of this study are useful for policymakers and planners in preparing contingency plans for typhoon events at the barangay level. This may include ensuring the welfare of the vulnerable age groups, and strict implementation of building code for structural design and constructions.

Keywords: evacuation behavior, internal validation, LR-based test logistic regression, parameter estimation

INTRODUCTION

The Philippines is located on the western part of the Pacific Ring of Fire where hydro-meteorological hazards such as typhoons, floods, storm surges are prevalent. Over the years, typhoons are becoming more frequent and severe. The tracks and time of occurrences of typhoons are also changing. The impacts of typhoons are becoming more catastrophic posing threats to the physical, physiological, and psychological aspects of human beings, and causing environmental degradation. There are eight to nine typhoons and another ten entering the Philippine area of responsibility (PAR) every year (Brown 2013). Two strong and destructive typhoons hit the Philippines from 2013 to 2014 which were called Haiyan and Hagupit, respectively. In 2013, Typhoon Haiyan with local name "Yolanda", a Category 5 storm, made landfall in the Eastern Visayas region, with a wind speed of more than 241 kph, affecting more than 14 million people in 44 provinces It displaced 4.1 million people, claimed the lives of more than 6,000 people, left 1,800 missing, and caused damage over USD 5.8 billion (Reid 2018).

Typhoon Hagupit succeeded Typhoon Haiyan in 2014. It reached a maximum sustained wind speed of 215 kph near the center, and gustiness of 250 kph, the strongest typhoon recorded that year (APAD 2015). The central and northern parts of the province were heavily affected leaving 2.9 million people (694,300 families) homeless (UNOCHA 2014). According to UNOCHA (2014), there were around 8,700 damaged houses, 39,100 partially damaged houses and 19 reported deaths. Around 3,003 evacuation centers were prepared before the disaster and accommodated 788,500 during the event.

The Philippines adopted and implemented the Sendai Framework for Disaster Risk Reduction in 2015. The main goal of the Sendai Framework is for nations to prevent and reduce disaster risks. This is by integrated and inclusive measures in all dimensions of society that prevent and reduce exposure to hazards and vulnerability and increase preparedness that will eventually strengthen resilience. Evacuation is one of the components that ensure effective preparedness to

reduce disaster risks (Lim et al. 2016). It is a process that includes hazard detection and assessment, warning, moving people to identified shelters, and return entry (Lim et al. 2013). Evacuation planning is important for the implementation of the evacuation process (Lumbroso et al. 2011). Assumptions are used to define threats and measures within the evacuation operation (Kolen and Helsloot 2014). However, one needs to understand the behavioral determinants of household or individual evacuation decision whether to evacuate or not. Analyzing and identifying these determinants is crucial in planning and implementation of evacuation, especially in the compliance and allocation of resources (Lim et al. 2016).

Studies in understanding the determinants of evacuation decisions have been done in engineering and social research areas. These determinants are categorized as socio-demographic, economic, environmental, and hazard-specific factors, among others. Specific factors include gender, income, presence of elderly people, vehicle ownership, use of the internet and social media, availability of mobile applications related to evacuation management, presence of younger adult or children, previous trauma associated with evacuation experience, and frequency of receiving warning orders (Lim et al. 2016; Goodie et al. 2019; Ahmed et al. 2020; Buylova et al. 2020; Wang et al. 2021). Household size is also a factor like in the case of wildfire evacuation decisions (Lee et al. 2018; Toledo et al. 2018).

Hazard-related factors such as perceived risk, and initial locations of household members significantly affect decisions (Lim et al. 2016; Meyer et al. 2018; Chen et al. 2021). Experience and knowledge on the strength and wind speed of typhoon in the past is associated to a lower likelihood of evacuation from the area at risk of hazard (Buylova et al. 2020; Meyer et al. 2018). Moreover, recent studies in emergencies indicated that people are more likely to work with others instead of behaving individually (Cuesta et al. 2021; Wang et al. 2021). Housing and employment type, and proximity to high-risk areas where people do not feel safe staying at home more likely contribute to evacuation compliance (Pan 2020).

It was observed in earlier studies that most of these were data-driven, and findings vary across different hazards and intensities. Factors affecting people's decisions are based on their priorities and specific disasters. Despite several studies in the past, investigation of evacuation travel behavior in the onset of typhoons is still inadequate. Thus, this study was conducted to identify and analyze the determinants of the evacuation decision of households affected by Typhoon Hagupit in Borongan City, Eastern Samar.

METHODS

Study Area

On 06 December 2014, Typhoon Hagupit ravaged Northern, Eastern Samar, and Samar provinces in the Eastern Visayas Region among other areas in the Philippines (UNOCHA 2014). Typhoon Hagupit left the Eastern Visayas region with 15 casualties, and 855 people injured (NDRRMC 2014). Among the areas that experience the onslaught of Hagupit in Eastern Samar is Borongan City.

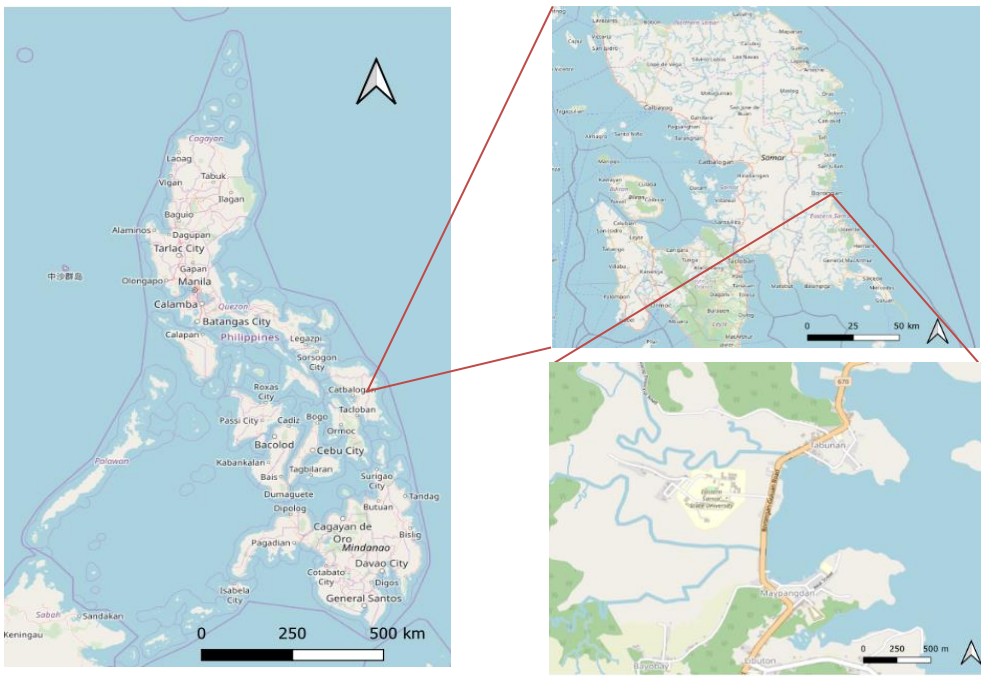

Figure 1. Location map of Maypangdan, Borongan City, Eastern Samar.

Borongan City is the provincial capital of Eastern Samar, Philippines (Figure 1). The center of the city is situated along the northern banks of the Loom River, and near the shoreline of Borongan Bay. Borongan City is located along the middle coastal area of Eastern Samar. It faces the Pacific Ocean on the east, the municipality of San Julian on the north, and the municipality of Maydolong on the South. On the west are the municipalities of Hinabangan, Calbiga, Pinabacdao, and Basey. The city of Borongan experiences various natural disasters such as typhoons, earthquakes, flash floods, flooding, landslide, tsunami, and storm surge (Gaillard et al. 2009).

Maypangdan is a barangay in the city of Borongan, Eastern Samar with a population of 2,798 (4.04% of the total population of Borongan) based on the 2015 Census (PhilAtlas 2020). There are about 547 households recorded in Maypangdan (NSO 2012). Considering the most affected area in Borongan City during the onslaught of Typhoon Hagupit, Barangay Maypangdan was specifically selected because it is considered the most vulnerable barangay in the city both geographically and demographically. Maypangdan is where the Eastern Samar State University-Main Campus is located. In the area, there are many transient residential areas and student boarding houses ranging from small temporary cottages to permanent and concrete structures.

Data Collection

For analyzing evacuation decision, data used in this study were collected through face-to-face interviews with household heads in the Barangay Maypangdan. Since there were less than 600 households recorded in Maypangdan, less than half of this was targeted as respondents. The households that were interviewed were selected using purposive sampling technique. The selection of household heads was done by talking to those who were in the areas near the coasts when the survey team went there. Two hundred ten (210) households were approached but only 200 agreed to be fully interviewed. The respondents were first requested to provide their consent for interview after introducing the intention and details of the questionnaire. The survey instrument elicited socio-demographic and capacity-related information. The former included the profile of the head of the household such as age (AGE), gender (GEN), work (WORK), education (EDUC), income (INCOM), marital status (MAR), the presence of children utmost 10 years of age (ACHILD), the number of household members (MEM), and the presence of elderly at least 60 years old (SEN). The capacity-related information elicited includes the house ownership (HOWN), house materials (HMAT), and the number of house floors (FLOOR). The respondents were also asked whether households evacuated or not (EDEC), and evacuated before or during the onslaught of Typhoon Hagupit.

After collection of information from households, the raw data were encoded and cleaned. Then, data were presented, classified based on categories, and summarized data were validated. The observations with invalid and missing data were removed. This resulted to 164 valid observations that were used for analysis. This number of samples covers less than 30% of the sample population considering an analysis at a 95% confidence level.

Parameter Estimation

Before employing logistic regression, the intercorrelation of the variables were analyzed to better understand if there exists a direct relationship between the variables considered for analysis. The correlation coefficients between two variables indicated a significant direct or indirect relationship between variables. The existence of the relationship between variables affected the selection of variables included in the logistic regression model.

After this, logistic regression was used to estimate the parameter of the evacuation decision (EDEC). The utility function for EDEC (EV_{ih}) is given in (Eq. 1). It consists of systematic terms ($\beta' Y_{sih}, \beta' Z_{cih}$) and a random term ($\varepsilon_{ih}$). The vectors Y_{sih} and Z_{cih} represent the household characteristics and capacity-related factors, respectively, that determined the EDEC, *i*, of a household, *h*. The ε_{ih} is the error term corresponding the effects of unobserved attributes, differences in preference among others, concerning the choice variable.

$$EV_{ih} = \beta' Y_{ih} + \beta' Z_{ih} + \varepsilon_{ih} \qquad \text{(Eq. 1)}$$

Equation 2 presents the probability of EDEC outcomes being chosen, *j*, by households, *h*. The maximum likelihood estimation was used to determine the coefficients, β, in equation (1), and log-likelihood function in (Eq. 3). Stata software version 13.1 was used to estimate the parameters for the choices on evacuation decision. The stepwise backward elimination method was used to select the variables included in the model (Steyerberg et al. 2004).

$$P_{ih} = \frac{e(\beta\prime Y_{sih} + \beta\prime Y Z c_{ih})}{\sum_i^j e(\beta\prime Y_{sih} + \beta\prime Y Z_{cih})} \qquad \text{(Eq.2)}$$

$$LL = \sum_{i=1}^{J} \sum_{h=1}^{H} \log(P_{ih}) \qquad \text{(Eq. 3)}$$

Model specification validation was tested through the LR-based statistical test. The model goodness of fit was evaluated based on McFadden pseudo-R^2. Further, the receiver operating characteristics (ROC) together with the area under the curve (AUC) were used to distinguish and evaluate the

outcomes with a 0.5 cut-off point. The AUC indicated the probability of sensitivity (desired outcome) and specificity (base outcome). AUC ranges from 0 to 1. The model can discriminate when it comes closer to 1. Models with AUC from 0.9 to 1, from 0.8 to less than 0.9, and 0.7 to less than 0.8, indicate outstanding, excellent, and acceptable discrimination, respectively (Hosmer and Lemeshow 2000). Moreover, the correct classification rate (CCR), determined as the sum of squares of the probability of the outcomes, was used to evaluate the predictive performance of the model. The base rate of the choices was compared to the predictive ability of the model developed (Liu et al. 2014). The increase in the predictive ability of the model showed the improvement in prediction accuracy brought about by the addition of significant variables.

Model Validation

Internal model validation was used for the assessment of the validation of the model. Likelihood Ratio (LR) test was specifically employed. It assumes a null hypothesis where the parameters of the model estimated using the whole data have no significant difference with that of the two subgroups from the whole data. It then means that the specification of the model is established when the null hypothesis is not rejected (Hasan et al. 2013). Then the LR test is given in (Eq. 4) below.

$$LR = -2\left[LL(\beta_{whole}) - LL(\beta_{sample1}) - LL(\beta_{sample2})\right] \quad \text{(Eq. 4)}$$

In this equation, $LL\ (\beta_{whole})$ is the pooled data model log-likelihood; $LL\ (\beta_{sample1})$, is the log-likelihood at the convergence of model 1 using the first group of data randomly selected from the whole data; then $LL\ (\beta_{sample2})$ is the loglikelihood at the convergence of the model of sample group 2 from the whole data.

RESULTS

Descriptive Statistics

Table 1 presents the distribution of the 164 observations by household characteristics and capacity-related variables. The variable categories and the mean of selected variables such as AGE, INCOME, MEM and ACHILD are also indicated. It should be noted that the variables in the data are categorized as shown in the second column in Table 1. Accordingly, most of the respondents (76.83%) disclosed that they evacuated during Typhoon Hagupit while 23.17% of the respondents did not. Almost half of the respondents (46.34%) were 51 years old and above. More than half of the respondents (57.32%) are male. Married status had the largest distribution among the respondents (81.10%). In terms of EDUC, 48.78% of them finished high school level. In terms of their occupation, 43.29% were self-employed, 26.83% were unemployed, and 15.24% were employed in the private sector. Most of the respondents (87.20%) reported that the household earned a monthly income of less than PHP 10,000.

Moreover, 45.73% of the respondents divulged that the household had less than four members. Also, 62.80% of the respondents do not have children who were 10 years old and younger. Absence of senior in the household comprised 68.29%. Further, most of the respondents (89.63%) revealed that they do not own their house. This can be attributed to the result where most of the respondents reported to have low household income. Hence, are unable to own a house. In terms of HMAT, most of the respondents (65.24%) were living in a house made of wood and/or light materials. With FLOOR identified, 82.32% and 17.68% of the respondents live in one-floor and two-floor houses, respectively.

Variable Correlation

The correlation analysis of EDEC and the other independent variables (Table 2) indicate that ACHILD (r = 0.273) positively correlated with EDEC. Conversely, AGE (r = -0.206), SEN (r = -0.247), HMAT (made of concrete materials) (r = -0.258), and the more than one-floor level (r = -0.162) were negatively correlated to EDEC. Furthermore, these correlation values were significant ($P < 0.05$). The summary of correlation coefficient results, however, gave information on the effect of each variable individually against EDEC. This indicates, a logit model was estimated to evaluate the relationship of EDEC to the other variables in a single model (Table 3).

Model estimation

The resulting logistic regression model estimate (Table 3) is statistically significant ($P < 0.01$). This means that the relationship of the dependent variable, EDEC, and independent variables such as ACHILD, SEN, MAT, and FLOOR collectively exist. Additionally, the estimation resulted in a McFadden R^2 of 0.146. Further, the AUC of the model in this study is 0.775 which is an acceptable level of discrimination of the EDEC choices. Notice that AGE was not mentioned as a significant factor, but it was correlated with other significantly correlated variables like the ACHILD, SEN, and HMAT (Table 2). This explains the significant direct relationship among these variables that also led to the selection of variables included in the model.

Table 1. Socio-demographic profile and capacity-related information of all respondents with valid data from Maypangdan, Borongan City, Eastern Samar (n = 164).

Variable	Category	Number	Mean	Percentage
Evacuation Decision (EDEC)	Did evacuate	126		76.83
	Did not evacuate	38		23.17
Age of the head of the household (AGE)	< 30	18	50.35	10.98
	31–50	70		42.68
	> 51	76		46.34
Gender of the household head (GEN)	Male	94		57.32
	Female	70		42.68
Civil status of the head of the household (MAR)	Single	13		7.93
	Married	133		81.10
	Widow	18		10.98
Educational attainment of the household head (EDUC)	Elementary	39		23.78
	Highschool	80		48.78
	College	45		27.44
Work of the head of the household (WORK)	Government employee	19		11.59
	Self-employed	71		43.29
	Unemployed	44		26.83
	Private employee	25		15.24
	Others (retired, etc.)	5		3.05
Monthly income of the household (INCOM)	≤ 10,000	143	4,746.22	87.20
	10,001–20,000	14		8.54
	20,001–30,000	7		4.27
Number of household members (MEM)	≤ 4	75	5.16	45.73
	> 4	89		54.27
Number of children utmost 10 years of age (ACHILD)	None	103	0.71	62.80
	Have child ≤ 10 years old	61		37.20
Presence of senior (i.e. > 60 years of age) (SEN)	No senior member	112		68.29
	Have senior member	52		31.71
House ownership type (HOWN)	Not owned	147		89.63
	Owned	17		10.37
House material (MAT)	Wood/ light materials	107		65.24
	Concrete	38		23.17
	Half-concrete	19		11.59
Number of floors (FLOOR)	One	135		82.32
	Two	29		17.68

For household characteristics ACHILD and SEN appears to be significant factors to the decision. The coefficient of variable ACHILD (β = 1.234) is positive. This means that a household that has children who are 10 years old or younger will more likely evacuate compared to those that do not have such children. The odds of a household that has children 10 years of age or younger deciding to evacuate is 3.434 times higher than those households that have no children of this age. Further, SEN showed a negative coefficient (β = -0.786), yet it is significant at a 90% level of confidence. This means that a household that has a senior member is less likely to evacuate. Also, the odds of households that have senior members and not evacuating is 0.455 times that of those households that have no senior members. These households find it difficult to evacuate because senior members prefer to stay at home than move, maybe due to their health conditions.

For capacity-related factors, HMAT and FLOOR had shown to be significant factors at a confidence level of 95% and 90%, respectively. HMAT has a negative coefficient (β = -0.603) which means that those with houses built with concrete materials are less likely to evacuate than those whose houses are built with wood or light materials. Moreover, FLOOR shows a negative coefficient (β = -0.803) which means that households that have two floors are less likely to decide to evacuate than those households that have one house floor level. The odds of households with a house of two-floor levels not evacuating is 0.448 times higher than households with one-floor houses. Households whose house is built with concrete materials and has two floors provide a sense of safety and security against the impacts of the hazard.

Table 2. Intercorrelation of the variables used for evacuation decision analysis (n = 164). *Significant at 0.05 level

Variables	Evacuation decision	Age	Gender	Household head work	Educational level	Income	Marital status	No. of Children	No. of Members	Presence of senior	House ownership	House materials	No. of house floors
Evacuation decision	1.000												
Age	-0.206*	1.000											
Gender		-0.143	1.000										
Household head work		-0.139		1.000									
Educational level		-0.142			1.000								
Income					0.286*	1.000							
Marital status		-0.218*	-0.152*	0.261*			1.000						
No. of Children	0.273*	-0.539*		0.243*			0.255*	1.000					
No. of Members							0.217*	0.175*	1.000				
Presence of senior	-0.247*	0.403*		-0.249*			-0.309*	-0.362*		1.000			
House ownership		-0.150								-0.146*	1.000		
House material	-0.258*	0.278*		-0.199*	0.212*	0.167*		-0.205*		0.225*		1.000	
No. of house floors	-0.162*						0.138						1.000

Table 3. Model estimation results for evacuation decisions for households that evacuated. *0.05 level of significance; **0.01 level of significance. CCR – correct classification rate; AUC – area under the curve.

Variable	Coefficient (β)	Odds Ratio	SE	Z	$P>\|z\|$	95% Confident Interval	
Constant	1.694	5.440	0.379	4.47	0.000	0.951	2.436
Household characteristics							
Indicator variable for ACHILD (1 for households with children aged ≤ 10, 0 otherwise)	1.234*	3.434	0.545	2.26	0.024	0.166	0.476
Indicator variable for SEN (1 for those with senior citizen, 0 otherwise)	-0.786**	0.455	0.426	-1.85	0.065	-1.620	0.476
Capacity-related factors							
Indicator variable for MAT (1 for house material with concrete, 0 otherwise)	-0.603*	0.547	0.271	-2.22	0.026	-1.134	-0.071
Indicator variable for FLOOR (1 for more than 1 floor, 0 otherwise)	-0.803**	0.448	0.482	-1.67	0.095	-1.747	0.141
Number of observations		164					
LR chi^2 (4)		25.92					
Prob > Chi^2		0.0000					
Log-likelihood convergence		-75.82					
Log-likelihood at 0		-88.78					
McFadden R^2		0.1460					
CCR		75.61%					
CCR base rate		64.40%					
AUC		0.7750					

Model Validation

The LR calculated for model validation is 3.292 with a DF of 4. At 0.05 level of significance, and DF of 4, the critical value of $\chi^2_{0.05, 4}$, is equal to 9.488. Since the LR value is less than the critical value, this indicates that the model result is established.

DISCUSSION

Findings in this study show that the variables determining evacuation decision include the presence of children 10 years of age and below, the presence of elderly of at least 60 years of age, a household with concrete houses, and the number of house floors. Although the presence of household members aged 60 years and above and the number of house floors appears to be significant at 90% confidence level, the variables are still included due to its significant correlation to evacuation decision as presented in Table 2.

Some of the findings correspond with previous studies where households with younger children are more likely to evacuate (Lim et al. 2013, 2016; Toledo et al. 2018). Goodie et al. (2019) stated that younger children in a household will have a high possibility to evacuate compared to the adults. This is because younger children were instructed several times as shown in Goodie et al. (2019) studies. Results on house materials is supported by Lim et al. (2016) who found out that households with a house built with concrete materials are less likely to evacuate than those made of wood. Moreover, results on the number of house floors are consistent with that of Lim et al. (2016, 2019) in the case of a typhoon-induced flood in other areas. This may have indications of the possibility of model transferability for typhoon-induced flooding cases, in different areas.

The result of this study provides insights regarding the evacuation behavior of households. Government services can be improved to increase the compliance of households by catering to their needs during an evacuation. This is true especially to households with children aged utmost 10 years of age and elderly people. Government leaders may develop an emergency preparedness plan for this type of household with the help of other government agencies. Learnings from the successful implementation of measures such as the flood early warning system in the Philippines (GIZ 2012) can be adopted. The program helped increase the capacity of local communities towards decrease in flood risks. Moreover, researchers can expand this research to other areas and identify more factors such as hazard-related factors. Furthermore, determining evacuee's departure timing, destination choice, and mode choice can be investigated.

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Initiation of a professional development program for science instructional leaders within the technological pedagogical content knowledge (TPACK) framework

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ABSTRACT

Knowledge related to the effective use of educational technologies has become widely recognized as an important aspect of an educator's knowledge-based for the 21st century. The study sought to assess and measure the perception of elementary teachers handling science in Pasay City on their understanding of the Technological Pedagogical Content Knowledge (TPACK) framework and its related constructs. It also aimed to find out how science teachers used technology in general. Surveys, focus group discussions, and strengths, weaknesses, opportunities, and threats (SWOT) analysis methods were used to gather data. Thematic analysis was also used to interpret the responses qualitatively. For triangulation purposes, master teachers and science coordinators were also involved in the data gathering. Among the subscales of TPACK, science teachers' pedagogical knowledge (PK) garnered the highest mean (3.48), while technological knowledge (TK) obtained the lowest mean (3.17). Technological pedagogical knowledge (TPK) had a very strong positive relationship (r = 0.854), while TK was strongly correlated (r = 0.631) to overall TPACK. The overall TPACK and other TPACK subscales are found to have a significant relationship. As revealed in the FGD, science teachers frequently used ICT tools to explore, elaborate or demonstrate a concept to pupils to further their understanding. However, some of the teachers claimed that their level of confidence in using ICT tools did not meet the required skills. This resulted in a proposed professional development program focusing on the three features of the TPACK framework: pedagogy, technology, and content.

Keywords: focal group discussion, ICT, individual performance commitment and review form, SWOT analysis, triangulation

INTRODUCTION

Knowledge related to the effective use of educational technologies has become widely recognized as an important aspect of an educator's knowledge-based for the 21st Century. The integration of information and communication technology (ICT) in classrooms has been a challenge for the educational system that aims to address the needs and demands of the 21st century (Yousef Mai and Hamzah 2016). To fully cope up with these challenges, the educational system must continue to improve and develop. For this reason, there is a worldwide trend toward producing teachers with high teaching competency specifically in Science Education. To help science teachers to become competent facilitators of learning, the use of technologies in teaching a specific content in the classroom context, the epistemology of technological pedagogical content knowledge (TPACK) is used as a basis for designing a particular arrangement of courses for science teacher education programs to meet the needs of the 21st-century teacher education development (Mercado et al. 2019).

Specifically, teachers are urged to plan various teaching materials that instill creativity and important thinking among learners through ICT, Department of Education (DepEd) Secretary Leonor Magtolis Briones said. During the recent National DepEd ICT Summit, Briones underscored the essentials of integrating ICT in both teaching and governance for the delivery of quality, accessible and relevant basic education for Filipino learners (Montemayor 2018). Further, research studies showed that ICT motivates student learning, there are numerous assumptions that students have an interest in using ICT; they found it more pleasant, more appealing, and more motivating to review with ICT tools than by traditional means (Yousef Mai and Hamzah 2016). In addition, ICT gives assistance and complementary support for both teachers and students when it comes to effective learning with the use of computers as learning aids (Ghavifekr and Rosdy 2015). Abdullahi (2014) stressed that higher level thinking, problem solving, improved communication skills, and a thorough comprehension of the learning tools and concepts to be taught are all enhanced by ICT.

It also ensures the creation of a more effective interactive learning environment through the application of a learner-centered and activity-oriented approach to teaching and learning.

However, teacher's resistance to technology integration and utilization is still evident in several studies. Many factors influence the teacher's rejection of new technology as proposed by Mac Callum et al. (2014). First, the teachers' beliefs about the perceived value of the new technology "usefulness" and the perceived effort needed to learn to use the new technology "ease of use". Second influential factor is the teachers' skills in using and integrating digital technology into their teaching "digital literacy". Another reason for resistance to technology integration is the teacher's self-efficacy beliefs about their level of competence and their attitudes towards technology adoption. Lastly, ICT anxiety is considered by a teacher to experience a level of uneasiness over his/her impending use of ICT.

In addition to these factors, the impact of technology is also of paramount concern. DepEd Secretary Briones said in her speech during the launch of *"*Sulong Edukalidad*"*, "The standards of education quality are even made more challenging by technology." She also cited Professor Schwab, the Founder and Executive Chairman of the World Economic Forum, who said that a revolution is happening immediately, which is fundamentally changing the way we live – whether we are conscious of it or not (Briones 2019).

Given the foregoing discussions, the researchers embarked on a study with the question "What Professional Development Program is recommended that will help science teachers enhance their technological, pedagogical, and content knowledge (TPACK)?". More specific, the study aimed to answer the following questions: 1. To what level do science teachers possess the following TPACK subscales as assessed by themselves, by their master teachers, and by their peers specifically in technological knowledge (TK), content knowledge (CK), pedagogical knowledge (PK), technological content knowledge (TCK), technological pedagogical knowledge (TPK), pedagogical content knowledge (PCK), and technological pedagogical content knowledge (TPACK)? 2. How significant is the relationship between reported scores for the TPACK subscales and overall TPACK? and 3. How do Science teachers use technology in teaching?

METHODS

Research Design

This study used a descriptive type of research whereby the proponents presented the holistic view of how TPACK can be of significant influence and benefit to the teachers with mixed-method research procedures that were predicated on data interpretation using both qualitative and quantitative approaches.

The research utilized a quantitative approach whereby data is generated from a large sample whilst the second aim needed an in-depth interview and Focal Group Discussion (FGD) of the actual practices of science teachers with technology in their classroom and documentary analysis via Individual Performance Commitment and Review Form. This endeavor utilized the descriptive-correlational type of research since it is the appropriate method to determine the relationship among the sub-constructs of TPACK and overall TPACK of teachers handling science. On the other hand, a thematic analysis was done to document the responses of the respondents qualitatively.

Study Site and Respondents

The research was conducted in a public elementary school in the Division of City Schools of Pasay, one of the city schools in the National Capital Region of the Philippines.

A total of 224 science teachers were chosen purposively as the respondents to determine their level of TPACK and their level of practice in using technology in their classrooms. They were chosen as respondents because, according to Mercado (2019), these teachers have direct exposure to ICT integration and utilization in their teaching episodes. Likewise, master teachers and science coordinators were included to assess the TPACK of the science teachers to substantiate the quantitative results of this study. Since master teachers conduct class observation, science coordinators were tasked with overseeing and providing technical assistance to these teachers.

All science teachers were included as respondents, except those that were involved during the pilot testing of survey questions. This study did not consider the profiling of science teachers, like years of teaching experience and the like. This was intentionally done to fully discern the outcomes, effects, influences, and impact of having a sound TPACK of these teachers towards the assigned subject they are handling.

Research Instrument

The proponents used two-pronged approaches in carrying out this research. The first part was to quantitatively assess the level of understanding of teachers handling science on the seven TPACK sub-constructs, which include objectives 1 and 2. A survey was given to the respondents to determine this goal. The forms were structured using dichotomous and likert-scale based questions to properly give a numerical rating to the attributes of TPACK that are deemed to benefit the teachers based on their level of

understanding. This TPACK survey was adapted with permission from the questionnaire developed and utilized by Owusu (2014) in New Zealand.

Furthermore, a FGD was used as the second part to determine the more intrinsic answers of the respondents. To formally study the locale, the researchers asked permission from the division involved. After the approval was given, the schools under study were duly notified by the researchers to properly inform the teachers of their rights to join in the said group discussion. The proponents also asked experts in the field to validate the questionnaires and FGD plot guide. The questionnaires underwent language and content validation to ensure quality assurance of the conciseness and alignment of the questions. The validators consisted of two language teachers and three science experts – an education program supervisor and a department heads.

The FGD was done in two sessions, dividing the participants into two groups to give every participant ample time to share or discuss his or her thoughts and elicit good responses from the other participants on a certain topic. Meanwhile, for the documentary analysis, the researchers asked the FGD participants to voluntarily submit a copy of their Individual Performance Commitment and Review Form (IPCRF). The data was analyzed by looking into the scores of the participants. The ratings for each objective of the IPCRF were recorded and interpreted.

Moreover, strengths, weaknesses, opportunities, and threats (SWOT) analysis was also used to determine the strengths, weaknesses, opportunities, and threats that were revealed in the study in both quantitative and qualitative results. The result of this analysis would serve as a baseline for the creation of the professional development program.

Data Analysis

The study used the traditional tables and charts to present the knowledge level of science teachers in all TPACK subscales. Furthermore, to provide for basic data interpretation in terms of the varied and collective relationship of TPACK with the respondents based on the latter's profile, mean ratings, and standard deviation were used. A Pearson *r* correlation analysis was used to test the null hypothesis that there is no significant relationship between the overall TPACK and other TPACK subscales. The proponent used SPSS software to analyze the data.

For the qualitative portion, the researchers meticulously transcribed each response given by the selected sample group. The responses from the focal group discussion were analyzed narratively. Information gathered was arranged into categories or themes and analyzed thematically as suggested by Riessman (2008). In this study, the narratives were written with minimal interpretation.

RESULTS

Degree of Science Teachers' TPACK Subscales

Technological knowledge (TK). All remarks had "Agree" adjectival ratings, indicating that the teachers are proficient in their TK (Table 1). The greatest weighted mean (± sd) was 3.29 ± 0.521 for statement 1, while the lowest was 3.04 ± 0.586 for statement 7. One FGD participant stated that there was a fear of employing technology. According to the teacher, he lacked confidence in his ability to use such ICT tools, which hampered his ability to use technology.

Content knowledge (CK). The teachers were also competent in terms of CK (overall mean (± sd) of 3.42 ± 0.353 and adjectival rating of Agree) which signifies that science teachers are competent (Table 2). The Statement 1 obtained the highest mean (± sd) which is 3.55 ± 0.498 with an adjectival rating of "Strongly Agree", while Statement 8 got the lowest mean (± sd) of 3.28 ± 0.468 and an adjectival rating of "Agree".

Pedagogical knowledge (PK). The data for the total PK of Science teachers as determined by the three groups (Table 3). The highest mean (± sd) of 3.52 ± 0.518, with an adjectival rating of "Strongly Agree," was reached by statement 6. As a result of this finding, science teachers are extremely skilled at developing and maintaining classroom management that is appropriate for a wide range of students. On the other hand, Statement 1 "assessing student performance in a classroom" had the lowest mean (±sd) of 3.39 ± 0.501, with an adjectival rating of "Agree."

Technological content knowledge (TCK). Teachers were competent in terms of TCK (overall mean of 3.38 ± 0.401 and adjectival rating of Agree) as shown in Table 4. Statement 3 received the highest mean (±sd) of 3.45 ± 0.156 while statement 6 got the lowest with a mean (±sd) of 3.28 ± 0.507.

Technological pedagogical knowledge (TPK). The science teachers are competent in terms of TPK where all statements had "Agree" as adjectival ratings (Table 5). They are competent in deciding what technologies are appropriate for their teaching as reflected by statement 2 having the highest mean (±sd) of 3.42 ± 0.529, while statement 5 garnered the lowest mean (3.26 ± 0.480).

Pedagogical content knowledge (PCK). Statement 1 had the greatest mean (±sd) of 3.48 ± 0.535, and an adjectival rating of "Agree," according to the data in Table 6. This indicates that teachers are capable of selecting effective techniques that help students think and learn about the subject matter. On

Table 1. Technological knowledge of science teachers in a public elementary school in the Division of City School of Pasay.

Statement	Mean	Standard deviation (±sd)	Adjectival Rating	Interpretation
1. having the technical skills I need to use technologies	3.29	0.521	Agree	Competent
2. knowing about a lot of different technologies	3.19	0.483	Agree	Competent
3. keeping up with important new technologies	3.27	0.544	Agree	Competent
4. learning to use new software on my own	3.21	2.083	Agree	Competent
5. having sufficient opportunities to work with a range of technologies	3.13	0.538	Agree	Competent
6. installing a new program that I would like to use	3.06	0.511	Agree	Competent
7. solving my technical problems of technologies	3.04	0.586	Agree	Competent
Overall	**3.17**	**0.498**	**Agree**	**Competent**

Table 2. Content knowledge of science teachers in a public elementary school in the Division of City School of Pasay.

Statement	Mean	Standard deviation (±sd)	Adjectival Rating	Interpretation
1. sufficient knowledge about the subject I teach	3.55	0.498	Strongly Agree	Highly Competent
2. various ways and strategies of developing my understanding of the subject I teach	3.45	0.507	Agree	Competent
3. a deep and wide knowledge of the subject that I teach	3.47	0.526	Agree	Competent
4. planning the scope and sequence of concepts that need to be taught within my class	3.46	0.509	Agree	Competent
5. various examples of how my subject matter applies in the real world	3.44	0.515	Agree	Competent
6. the scientific way of thinking	3.36	0.491	Agree	Competent
7. good knowledge of the Nature of Science (NOS)	3.37	0.502	Agree	Competent
8. up-to-date resources and developments in my subject area	3.28	0.468	Agree	Competent
Overall	**3.42**	**0.353**	**Agree**	**Competent**

Table 3. Pedagogical knowledge of science teachers in a public elementary school in the Division of City School of Pasay.

Statement	Mean	Standard deviation (±sd)	Adjectival Rating	Interpretation
1. assessing learner performance in a classroom	3.39	0.501	Agree	Competent
2. adapting my teaching based upon what learners currently understand or do not understand	3.50	0.510	Strongly Agree	Highly Competent
3. adapting my teaching style to cater to diverse learners.	3.43	0.505	Agree	Competent
4. using a wide range of teaching approaches in a classroom setting	3.42	0.522	Agree	Competent
5. using different assessment tools and techniques	3.44	0.515	Agree	Competent
6. organizing and maintaining classroom management	3.52	0.518	Strongly Agree	Highly Competent
7. determining the strategy best suited for the lessons I teach	3.50	0.510	Strongly Agree	Highly Competent
8. preparing lesson plans for the various topics I teach	3.50	0.501	Strongly Agree	Highly Competent
Overall	**3.48**	**0.385**	**Agree**	**Competent**

Table 4. Technological content knowledge of science teachers in a public elementary school in the Division of City School of Pasay.

Statement	Mean	Standard deviation (±sd)	Adjectival Rating	Interpretation
1. understanding technologies that I can use for teaching specific concepts in my subject matter	3.42	0.520	Agree	Competent
2. knowing how my subject matter can be represented by the application of technology	3.40	0.500	Agree	Competent
3. knowing about technologies that I can use for enhancing the understanding of specific concepts in my subject matter	3.45	0.516	Agree	Competent
4. using technological representations (i.e. multimedia, visual demonstrations, etc.) to demonstrate specific concepts in my subject matter	3.44	0.557	Agree	Competent
5. using various types of technologies to deliver the content of my subject matter	3.33	0.549	Agree	Competent
6. using technology to make students observe a phenomenon that would otherwise be difficult to observe in my subject matter	3.28	0.507	Agree	Competent
7. using technology to create and manipulate models of scientific phenomenon (e.g. animations, modeling, etc)	3.33	0.558	Agree	Competent
Overall	**3.38**	**0.401**	**Agree**	**Competent**

Table 5. Technological pedagogical knowledge of science teachers in a public elementary school in the Division of City School of Pasay.

Statement	Mean	Standard deviation (±sd)	Adjectival Rating	Interpretation
1. choosing technologies that enhance the teaching approaches for a lesson	3.37	0.511	Agree	Competent
2. choosing technologies that are appropriate for my teaching	3.42	0.529	Agree	Competent
3. choosing technologies that enhance learners' learning of a concept	3.36	0.526	Agree	Competent
4. applying technologies to different teaching activities	3.36	0.533	Agree	Competent
5. managing a technology-rich classroom effectively	3.26	0.480	Agree	Competent
6. using technology to help assess pupil learning	3.29	0.517	Agree	Competent
7. using technology to actively engage learners in teaching and learning.	3.31	0.551	Agree	Competent
Overall	**3.34**	**0.401**	**Agree**	**Competent**

the other hand, Statement 8 had the lowest mean of 3.34 ± 0.493 and an adjectival rating of "Agree." Surprisingly, teachers were also competent in terms of their total PCK with weighted mean of 3.41 and an adjectival rating of "Agree".

Technological pedagogical content knowledge (TPACK). The total mean (±sd) is 3.33 ± 0.395 and an adjectival rating of "Agree," indicating that teachers are proficient in their TPACK (Table 7). The greatest weighted mean (± sd) was 3.37 ± 0.511 for statement 1, while the lowest were 3.31 for statements 2, 3 and 4.

Relationship Between Overall TPACK and TPACK Subscales.

The relationship between overall TPACK and other TPACK subscales of science instructional leaders is exhibited in Table 8. It should be noted that the correlation coefficients for all TPACK subscales ranged from 0.631 to 0.854, indicating a strong to very

strong link when compared to total TPACK. TPK had a strong positive association (0.854) with overall TPACK, while TK had a high positive relationship (0.631). The null hypothesis that there is no significant link between total technological pedagogical content knowledge (TPACK) and other TPACK subscales is thus rejected because the *P*-value, which is 0.000 in all subscales, is lower than the given level of significance (0.05).

Use of Technology in Teaching Science

The participants in the focal group discussion (FGD) indicated that they regularly used technology to support the teaching and the learning of their pupils. All the teachers used ICT tools frequently to explore, elaborate or demonstrate a concept to pupils to further their understanding. Again, the teachers frequently allowed their pupils to observe images through ICT tools and most of them regularly used presentational software to deliver content material to pupils. They asserted that it brought higher pupil engagement, facilitated better pupil's understanding of concepts and provided avenues for pupils' out of learning and continuous learning.

DISCUSSION

Level of Science Teacher's Technological Pedagogical and Content Knowledge (TPACK)

As revealed in the study, pedagogical knowledge had the highest mean, similar to the findings made by Yousef Mai and Hamzah (2016), where primary science teachers perceived higher self-confidence in PK in general. This describes those science teachers who are competent in the processes and practices of teaching and learning. It includes knowledge about classroom management and organization; curricular analysis and planning; and student learning (Roig-Vila et al. 2015). This is followed by CK and PCK.

Meanwhile, TK obtained the lowest mean, followed by TPACK. Roig-Vila et al. (2015) underscored that TK encompasses knowledge about diverse technologies, evolving from low-tech technologies like paper and pencils to digital technologies such as the use of the internet, digital video, interactive whiteboards, and others. This is like the findings made by Roig-Vila et al. (2015), where they discovered that teachers are more competent in terms of their PK and CK as compared to their TK. Furthermore, the teacher's TK does not meet or satisfy the ICT integration into their teaching episodes. In contrast, Yousef Mai and Hamzah (2016) revealed in their study that science teachers had higher TK than the other TPACK subscales. Further, Blau et al. (2016) ascertained that professors' TK had significantly improved after using phenomenological research techniques and addressed in terms of TPACK and "digital wisdom" approaches. Only moderate links between technology and pedagogy, as well as technology and content, were discovered.

With regards to the overall TK of science instructional leaders, it was realized that they are competent when it comes to using technologies because they possess the technical skills they need, while "solving my technical problems with technologies" got the lowest weighted mean. One respondent in the FGD narrated that there was fear of using technology in the teaching episodes.

Table 6. Pedagogical content knowledge of science teachers in a public elementary school in the Division of City School of Pasay.

Statement	Mean	Standard deviation (±sd)	Adjectival Rating	Interpretation
1. selecting effective teaching approaches to guide learner thinking and learning in my subject matter	3.48	0.535	Agree	Competent
2. producing lesson plans with a good understanding of the topic in my subject matter	3.44	0.524	Agree	Competent
3. anticipating learner misconceptions within a particular topic	3.38	0.514	Agree	Competent
4. assisting learners in identifying connections between various concepts in my subject matter	3.38	0.495	Agree	Competent
5. distinguishing between correct and incorrect problem-solving attempts by students in my class	3.40	0.543	Agree	Competent
6. familiarizing with common learner understandings and misconceptions in my subject matter	3.39	0.507	Agree	Competent
7. meeting the objectives described in my lesson plans	3.42	0.521	Agree	Competent
8. targeting aspects of the Nature of Science when teaching explicitly	3.34	0.493	Agree	Competent
Overall	**3.41**	**0.381**	**Agree**	**Competent**

Table 7. Technological pedagogical content knowledge of science teachers in a public elementary school in the Division of City School of Pasay.

Statement	Mean	Standard deviation (±sd)	Adjectival Rating	Interpretation
1. teaching lessons that appropriately combine my subject matter, technologies, and teaching approaches	3.37	0.511	Agree	Competent
2. selecting technologies to use in my classroom that enhance what I teach, how I teach, and what students learn	3.31	0.502	Agree	Competent
3. using technology to create effective representations of content that departs from textbook approaches	3.31	0.518	Agree	Competent
4. using technology to facilitate scientific inquiry in the classroom	3.31	0.545	Agree	Competent
5. finding and using online materials that effectively demonstrate a specific scientific principle	3.33	0.550	Agree	Competent
6. choosing technologies that enhance the understanding of the content for a lesson	3.32	0.512	Agree	Competent
7. providing leadership in helping others to coordinate the use of content, technologies, and teaching approaches at my school	3.36	0.517	Agree	Competent
8. using strategies that combine content, technologies, and teaching approaches in my classroom	3.32	0.505	Agree	Competent
Overall	**3.33**	**0.395**	**Agree**	**Competent**

Table 8. Relationship between the science teachers' overall technological pedagogical and content knowledge and TPACK subscales.

Variables	N	Correlation Coefficient	Significant value	Strength of Relationship	Interpretation
TPACK*TK	224	0.631	0.000	Strong	Significant
TPACK*CK	224	0.732	0.000	Strong	Significant
TPACK*PK	224	0.773	0.000	Strong	Significant
TPACK*PCK	224	0.740	0.000	Strong	Significant
TPACK*TCK	224	0.831	0.000	Very strong	Significant
TPACK*TPK	224	0.854	0.000	Very strong	Significant
TPACK*TPCK	224	0.820	0.000	Very strong	Significant

Science teachers, on the other hand, were highly competitive concerning their knowledge of the subject they teach in terms of the overall CK. This is true of what Jauss (2002), posited that science teachers are expected to have mastery over the subject they teach. Further, it was also evident in the findings of Yousef Mai and Hamzah (2016) that claimed that science teachers were competent in applying science concepts as presented in the content, and theories for students to gain scientific knowledge.

In terms of the PK, science teachers should adopt various ways of assessing learner performance to address the diversity of learners. This supports the suggestion of Tanner (2018) that teachers should be able to understand how students construct knowledge and learn, as well as have appropriate and varied ways of assessing students.

Accordingly, science teachers are competent in understanding the technologies to be used for deepening learners' knowledge of specific concepts. This finding was supported by Neiss (2012) who found that teachers are required to have a comprehensive understanding of students' thinking and learning processes with the presence of digital technologies in their teaching for a particular subject matter.

Regarding the TPK, science teachers are competent in choosing and deciding what technologies are appropriate for their teaching. As Mishra and Koehler (2009) have mentioned, teachers should realize that the technology they want to use does affect their teaching approaches, methods, and design. This claim was also evident during the FGD, where teachers mentioned that using technology should

match the curriculum. Conversely, Statement 5 ("managing a technology-rich classroom effectively") clearly reveals that science teachers should organize and maintain an atmosphere where technology integration inside the classroom is well used. Kurt (2018) emphasized the use of ICT effectively and more frequently to solicit the utmost interest and interaction among the students.

It could be noted from the findings that teachers are competent in terms of their TK, PK, and CK. However, looking into some of the indicators mentioned in the results, teachers' competence needs to be addressed, especially in their TK. This means that science teachers must equip themselves with the ability to solve technical problems in technology on their own. Gonzales (2018) found that respondents struggle to come up with laboratory activities and lack knowledge about manipulating technical problems when using technology. In addition, by definition, technology is a tool that encourages and supports independent learning (Gonzales 2018).

Relationship Between Overall TPACK and TPACK Subscales

The overall TPACK is related to other TPACK subscales. This only shows that teachers should always consider the complex relationship among the TPACK constructs to empower them in the technology utilization that centers on student learning and fosters and develops inquiry learning among students, as Chai et al. (2013) mentioned. Likewise, Yousef Mai and Hamzah (2016) believe that TPACK is the knowledge expected of teachers to integrate technology into their teaching and content area. This means that those teachers are competent in delivering lessons that suitably consider the subject matter, technologies, and teaching approaches. But teachers must consider the appropriateness of a certain technology before using it to enhance the delivery of the lesson, understanding of concepts, and development of scientific inquiry among learners. It is then highly recommended for the elementary science teachers to be recalibrated and undergo upskilling through professional development programs and participate in such training, particularly in terms of integrating technology into content and pedagogy. Professional development can start before a teacher even begins teaching in the classroom and can go until the conclusion of a teacher's career, according to Luft and Hewson (2014).

A professional development program was formulated based on the TPACK framework, focusing on its three features: pedagogy, content, and technology. This proposal is in response to and for the realization of the goals and objectives of DepEd's "Sulong Edukalidad," an educational reform program aimed at achieving quality in basic education for young Filipinos. One of its four key reform areas is the upskilling and reskilling of the teachers. Thus, this professional development program is strongly proposed.

This proposed development program aims to provide fervent support to science teachers in enhancing instructional competence through the TPACK framework. It also seeks to capacitate science teachers towards quality instruction through effective ICT integration. Moreover, it also aims to recommend sound solutions that will improve instructional competence and will boost teachers' high morale in teaching science where content, pedagogy, and technology are given focus. It has three key areas of concern: technology, pedagogy, and content. It consists of four sub-areas: ICT integration in teaching the subject matter, responsive solutions to technical problems, assessment of learning, methods of teaching and learning, classroom management and subject matter, and teacher's learning resources.

This professional development program can be implemented after it receives approval from the school division office through the recommendation of the education program supervisor in science. The supervisor in-charge is tasked with disseminating the program's objectives to all elementary school principals. Then, these principals will implement this development program in their designated schools. Since each school is now conducting its own learning action cell (LAC) session, school principals will spearhead the activity through their Science Coordinators as the focal person. Only those training or activities that require specialist teachers or ICT instructors to assist colleagues will be undertaken by the school learning action cell.

At the school level, a monthly monitoring tool will be completed by the school principals and will be submitted to the supervisor in-charge. This monitoring tool focuses on the impact of a certain training or activity on science teachers.

To strengthen its implementation, a division-wide LAC will be conducted for all science teachers. This can be done in off-session episodes. All training or activities that need resource speakers will only be conducted through this mode—the division learning action cell (DLAC).

One finding that supports this claim was the study conducted by Angeli and Ioannou (2015), where teachers were taught how to think about the pedagogical affordances of different computer technologies and how to use them to make the computer science curriculum more understandable to learners during a 15-hour teacher professional development program. Teachers also learn how to think iteratively about technology, content, and pedagogy in order to create learning activities that are appropriate for the conceptual ecology of their students. The study shows instructors' real

instructional artifacts as they developed from their involvement in the teacher professional development program, as well as their evaluations of the program, to provide good instances of TPACK in action.

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Water quality of Puerto Princesa Bay in relation to the presence of informal settlers in its coastal areas

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ABSTRACT

In this study, the water quality of four coastal areas in Puerto Princesa Bay, with and without informal settlers, were compared in terms of the phytoplankton composition and density, fecal coliform and physicochemical parameters during a 12-month sampling period. Microscopic examination and identification using phytoplankton monographs showed five harmful algal blooms (HABs) genera (*Alexandrium*, *Dinophysis*, *Nitzschia*, *Pseudo-nitzschia*, and *Pyrodinium*) with *Dinophysis* spp. as the most abundant in coastal areas with informal settlers and *Pseudo-nitzschia* spp. in areas without informal settlers. Eight phytoplankton genera (*Coscinodiscus*, *Proboscia*, *Rhizosolenia*, *Skeletonema*, *Ceratium*, *Prorocentrum*, *Protoperidinium*, and *Oscillatoria*) reported to have caused algal blooms were also observed with *Coscinodiscus* spp. as the most abundant in both groups of coastal areas. Multiple-tube fermentation technique showed fecal coliform count ranging from 4 to >1600 most probable number (MPN)/100 ml in the coastal areas with informal settlers and from <1.8 to 295 MPN/100 ml in areas without informal settlers. Multiprobe measurements showed that both groups of coastal areas have similar physicochemical characteristics with only the dissolved oxygen failing to meet the Philippine standards for class SB waters. There was a significant difference ($P < 0.05$) in water quality between the coastal areas with and without informal settlers in terms of fecal coliform and the density of four phytoplankton genera (*Pseudo-nitzschia*, *Skeletonema*, *Alexandrium* and *Ceratium*). However, there is no significant difference in terms of the physicochemical parameters. Regression analysis indicates that the presence of informal settlers could affect water quality in terms of fecal coliform and the five phytoplankton genera (*Coscinodiscus*, *Pseudo-nitzschia*, *Skeletonema*, *Alexandrium* and *Ceratium*).

Keywords: blue-green algae, diatoms, dinoflagellates, fecal coliform, physicochemical properties, phytoplankton

INTRODUCTION

Puerto Princesa Bay, situated in the capital city of Palawan, is one of the major fishing grounds in the province. Because of its strategic location, the bay was subjected to influx of migrants who built their homes in the coastal areas (Gonzales 2004). The study of Cuebillas et al. (2016) stated that 4,680 households in Puerto Princesa City (9.8% of its total household population) are informal settlers, with 3,260 households living along the coastal areas of the city. The largest contributor of these informal settlers is Barangay Bagong Silang with 729 households (73.2% of its total household population), followed by Barangay San Pedro with 491 households (13.3% of its total household population). In addition, Barangay Bagong Silang has the highest number of households (60.8%) without access to sanitary toilet facility, while Barangay San Pedro comes fourth (7.5% of its total household).

Coastal communities with no sanitary toilets, directly discharge their wastes into the surface or coastal waters (DENR EMB-XI 2022). This discharge of untreated sewage wastewater may lead to water pollution problems such as eutrophication, algal growth, decrease in recreational uses of water, pathogen-causing diseases, excessive loss of dissolved oxygen, and undesirable changes in the population of aquatic resources (Owili 2003; Akpor and Munchie 2011).

Changes in water quality in the coastal areas can negatively affect the biotic components of the surrounding environment in various ways. First, many phytoplankton, including diatoms, dinoflagellates, and cyanobacteria can produce toxins or grow excessively resulting in harmful algal blooms (HABs). These

blooms may harm humans, causing illness or death from eating contaminated shellfish or fish, and may also cause massive mortalities of fish, seabirds and other marine mammals (Borja et al. 2019). Secondly, pathogenic bacteria from anthropogenic sources, can affect the quality of both wild fish and aquaculture resources, and consequently the health of the consumers (Raña et al. 2017). Lastly, the physical properties of water can influence the distribution of aquatic organisms while its chemical properties can affect the type of organisms' present (Shilpa et al. 2012).

Puerto Princesa Bay has been categorized as class SB by the DENR-EMB (2022) which indicates that its waters are suitable for commercial propagation of shellfish, as spawning grounds for milkfish and similar species, for ecotourism, and for primary contact recreation (DENR 2016). These intended uses of the bay were compromised when the Bureau of Fisheries and Aquatic Resources (BFAR) declared Puerto Princesa Bay to be positive for red tide toxin in 30 January 2017. This was the first recorded incidence of toxic red tide in the bay which lasted for five weeks. In the same year, the second incidence was reported in 03 July 2017, which lasted for twenty weeks. The red tide in Puerto Princesa Bay continued to recur in the following years, with the latest occurring from July 2019 until early February 2020 (BFAR 2017, 2018, 2019, 2020). The reported causative organism was *Pyrodinium bahamense* (Palawan News 2018).

This study was conducted to determine the water quality on the coastal areas of Puerto Princesa Bay, with the presence and absence of informal settlers, in terms of phytoplankton density and composition, fecal coliform, and physicochemical parameters. This study also determined if there is a significant difference between the water quality in the coastal areas with the presence and absence of informal settlers and whether the presence of informal settlers in the coastal areas could affect the water quality in Puerto Princesa Bay.

METHODS

Research Areas

This study was conducted at four coastal areas in Puerto Princesa Bay (Figure 1). Two areas, Purok Abanico (Brgy. San Pedro) and Quito (Brgy. Bagong Silang) are inhabited by informal settlers with houses built on stilts in the coastal waters. The other two areas, Caña Island (Brgy. Tiniguiban) and Brgy. Mangingisda, have no informal settlers living in its coastal waters. Caña Island is known for its abundant shells while Brgy. Mangingisda has a fish port and many fish pens.

Water Sampling

Water sampling was conducted once a month for 12 months from April 2018 to March 2019. The water samples were collected at 100 to 200 m from the shoreline between 08:00 to 12:00.

Phytoplankton composition and density determination. Three water samples were collected by towing horizontally below the water surface a 20 µm mesh size plankton net securely tied in a motorboat moving at low speed for 5 min. A flow meter (General Oceanic Inc., USA) was tightly bound to the plankton net. Water samples were placed in clean bottles, fixed with 3 to 5 ml of 10% formalin, and stored in a cooler.

The phytoplankton was quantified using a Sedwick-Rafter counting chamber with the aid of an inverted microscope (Cole-Parmer, USA) and photographed using android phone camera. Photographs of phytoplankton presented in this paper such as the identified and considered as harmful based on the following taxonomic monographs for diatoms, dinoflagellates, and blue-green algae (Al-Kandari et al. 2009; Okolodkov 2010; Kim et al. 2013) were taken using android phone camera and an LB-243 Biological Trinocular Microscope (USA) with digital camera from different water samples obtained throughout the 12-month sampling period. The harmful species were verified using the IOC-UNESCO Taxonomic Reference List of Harmful Micro Algae (Lundholm et al. 2009 onwards).

Phytoplankton density was calculated using the equation below:

$$N = n\ x\ \frac{v}{V}$$

where N = total number of phytoplankton cells L^{-1} of water filtered; n = number of phytoplankton cells in 1 ml sample; v = volume of phytoplankton concentration (ml); V = volume of water (L) filtered thru plankton (obtained from flow meter reading).

Fecal coliform analysis. A 350 ml water sample was collected by direct scooping in duplicate. The water samples were collected one foot below the water surface, placed in sterilized bottles, stored in a cooler, and delivered to the Department of Science in Technology–Mindoro Marinduque Romblon Palawan Regional Standards and Testing Laboratory (DOST-MIMAROPA RSTL) in Puerto Princesa City, with 4 to 7 h holding time. The Multiple-Tube Fermentation Technique was used to estimate the fecal coliform density which was expressed in most probable number (MPN)/100 ml.

Physicochemical analyses. Measurement on subsurface water were done in triplicate. The physicochemical parameters measured *in situ* were pH,

temperature, dissolved oxygen, and salinity. The pH was determined by dipping a pH meter (Lutron PH-223, Taiwan) on subsurface water while the temperature, dissolved oxygen and salinity were measured using a YSI Professional Plus Multiparameter Meter (USA). The total dissolved solid was measured *ex situ* at the Palawan State University–Marine Science laboratory (PSU-MSL) using HORIBA LACQUAact PC110 (Japan).

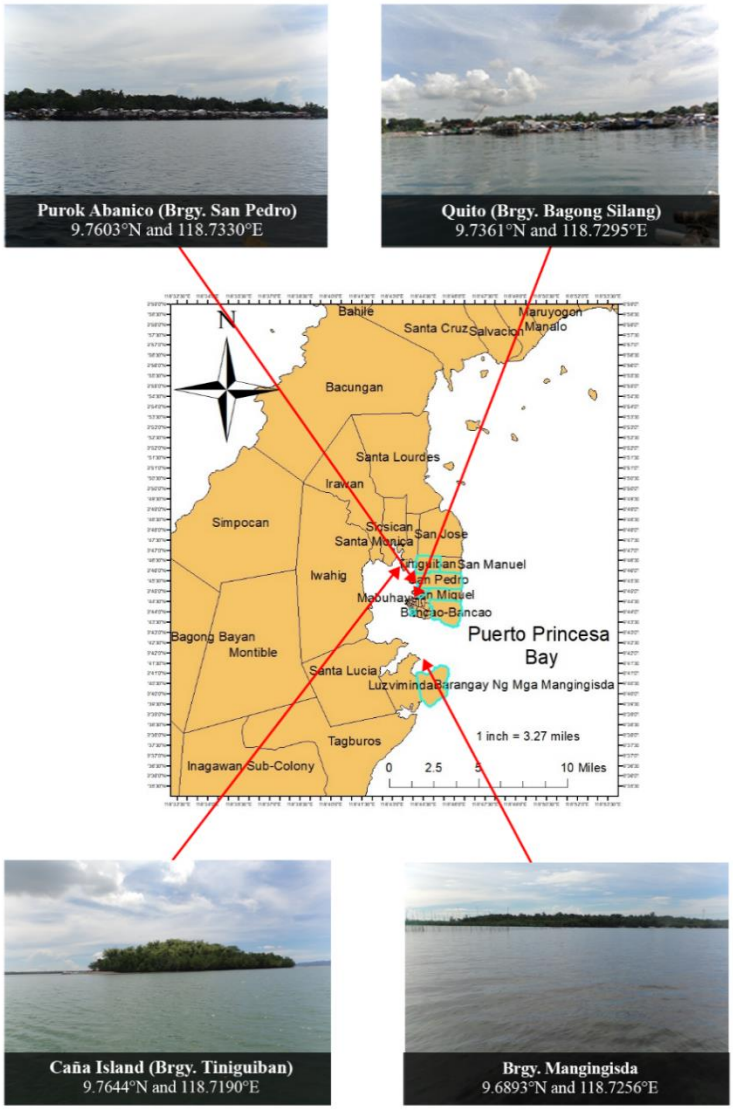

Figure 1. A map showing Puerto Princesa Bay and the four coastal areas as sampling sites.

Statistical Analysis

Kruskal Wallis was used to determine the significant difference between the water quality on the coastal areas with and without informal settlers. Logistic regression was employed to determine if the presence or absence of informal settlement in the coastal areas could affect the water quality. Both statistical methods were tested in terms of phytoplankton composition and density, fecal coliform, and physicochemical parameters.

RESULTS

Phytoplankton Composition and Density

The phytoplankton found in four coastal barangays fall under 13 genera. Of which, six were diatoms, six were dinoflagellates, and one was a blue-green alga (Table 1). The diatoms *Coscinosdicus* spp., *Nitzschia* spp., *Proboscia* spp., *Pseudonitzschia* spp., *Rhizosolenia* spp., and *Skeletonema* spp., and the blue-

green alga *Oscillatoria* spp. were observed in both coastal areas with the presence and absence of informal settlers. Four dinoflagellate genera were also present in both sites which include *Ceratium* spp., *Dinophysis* spp., *Prorocentrum* sp., and *Protoperidinium* spp. However, *Pyrodinium* sp. along with *Alexandrium* spp. were found only in coastal areas with informal settlers.

In the first coastal area inhabited by informal settlers, Purok Abanico (Table 2), *Coscinodiscus* spp. had the highest total density among the 11 species observed while *Proboscia* spp. and *Nitzchia* spp. had the lowest. In addition, *Coscinodiscus* spp. and *Ceratium* spp. were consistently present for 10 months (June 2018 to March 2019.) The highest phytoplankton density (23,086 cells L^{-1}) in Purok Abanico occurred in June 2018 while the next highest density was observed in January 2019. Four HABs genera were observed which were present from August to December 2018, with *Alexandrium* spp. as the most abundant (Table 2).

In the second coastal area with informal settlers, Quito (Table 3), *Rhizosolenia* spp. had the highest total density among the 12 species seen while *Pyrodinium* sp. had the lowest. *Ceratium* spp. was seen throughout the 12-month sampling period, while *Coscinodiscus* spp. and *Rhizosolenia* spp. appeared for a period of ten months. Similar with Purok Abanico, four HABs genera were observed in Quito which were present for six months, with *Dinophysis* spp. as the most abundant (Table 3).

In the first coastal area with the absence of informal settlers, Caña Island (Table 4), *Coscinodiscus* spp. had the highest total density among the 10 species found while *Proboscia* spp. had the lowest. *Coscinodiscus* spp. and *Ceratium* spp. appeared all throughout the 12-month sampling period. Two HABs genera were observed, with *Pseudo-nitzschia* spp. as the more abundant and was present for eight months (Table 4).

In the second coastal area without informal settlers, Brgy. Mangingisda (Table 5), *Coscinodiscus* spp. had the highest total density among the 11 species identified while *Oscillatoria* spp. had the lowest. *Coscinodiscus* spp. was seen throughout the 12-month sampling period while *Ceratium* spp. appeared in the water samples for a period of eleven months. June 2018 exhibited the densest phytoplankton species (23,479 cells L^{-1}) for this site followed by 3,768 cells L^{-1} in July 2018. Similar with Caña Island, the same two HABs genera were observed, with *Dinophysis* spp. as the more abundant but was only present for two months (Table 5).

Comparing the harmful phytoplankton species, three HABs genera (*Nitzschia*, *Pseudo-nitzschia*, *Dinophysis*) were present in both groups of coastal areas with *Dinophysis* spp. as the most abundant in the coastal areas with informal settlers and *Pseudo-nitzschia* spp. in the coastal areas without informal settlers. Two other HABs genera (*Alexandrium* and *Pyrodinium*) were observed only in the coastal areas with informal settlers with *Alexandrium* sp. as the more abundant.

The species of diatoms, dinoflagellates, and blue-green algae found in four coastal areas of Puerto Princesa Bay were presented in Figures 2,3, and 4, respectively.

Table 1. Composition of phytoplankton genera of four coastal areas in Puerto Princesa Bay. Harmful species (Lundholm et al. 2009 onwards) are written in bold. Note: √ (present); - (absent).

	Coastal areas with informal settlers		**Coastal areas without informal settlers**	
Phytoplankton Taxa	**Abanico**	**Quito**	**Caña**	**Mangingisda**
Diatom				
Coscinodiscus spp.	√	√	√	√
Nitzschia spp.	√	-	√	√
Proboscia spp.	√	√	√	√
Pseudonitzschia spp.	√	√	√	√
Rhizosolenia spp.	√	√	√	√
Skeletonema spp.	√	√	√	√
Dinoflagellate				
Alexandrium spp.	√	√	-	-
Ceratium spp.	√	√	√	√
Dinophysis spp.	√	√	√	√
Prorocentrum sp.	-	√	-	√
Protoperidinium spp.	√	√	√	√
Pyrodinium sp.	-	√	-	-
Blue-Green Algae				
Oscillatoria spp.	√	√	√	√

Table 2. Composition and density of phytoplankton in the coastal area of Purok Abanico. Harmful species (Lundholm et al. 2009 onwards) are written in bold.

Taxa	Density (Total number of phytoplankton cells L^{-1} of water filtered)											
	2018								2019			Total
	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	
Diatom												
Coscinodiscus spp.			23,069	512	341	1,671	767	341	409	6,172	648	341	34,271
Nitzschia spp.					17								17
Proboscia spp.		17											17
Pseudo-nitzschia spp.							68		239				307
Rhizosolenia spp.				2,285	34	17	136						2,472
Skeletonema spp.		1,961									648		2,609
Dinoflagellate													
Alexandrium spp.						324							324
Ceratium spp.			17	239	17	2,046	341	154	307	85	870	495	4,571
Dinophysis spp.						17	17	102					136
Protoperidinium spp.							102						102
Blue- Green Algae													
Oscillatoria spp.					34		375						409
Total		1,978	23,086	3,036	443	4,075	1,806	597	955	6,257	2,166	836	45,325

Table 3. Composition and density of phytoplankton in the coastal area of Quito. Harmful species (Lundholm et al. 2009 onwards) are written in bold.

Taxa	Density (Total number of phytoplankton cells L^{-1} of water filtered)											
	2018									2019		Total
	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	
Diatom													
Coscinodiscus spp.	1,773	17	495	1,535	682	972	341		341	8,372		3,223	17,751
Proboscia spp.		205	801	1,569									2,575
Pseudo-nitzschia **spp.**					239								239
Rhizosolenia spp.	699	2,864	1,091	1,790	290		392		1,552	2,080	938	13,248	24,944
Skeletonema spp.				699		136	580		307			1,859	3,581
Dinoflagellate													
Alexandrium spp.	51		324				17						392
Ceratium spp.	205	1,125	2,268	2,080	68	17	443	136	154	6,735	631	1,091	14,953
Dinophysis spp.	17		392		34	801				1,756			3,000
Prorocentrum sp.						68							68
Protoperidinium spp.	68		426		17		17	17		1,790			2,335
Pyrodinium sp.							34						34
Blue-Green Algae													
Oscillatoria spp.					188		1,876						2,064
Total	2,813	4,211	5,797	7,673	1,518	1,994	3,700	153	2,354	20,733	1,569	19,421	71,936

Table 4. Composition and density of phytoplankton in the coastal area of Caña Island. Harmful species (Lundholm et al. 2009 onwards) are written in bold.

Taxa	Density (Total number of phytoplankton cells L^{-1} of water filtered)												
	2018									2019			Total
	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	
Diatom													
Coscinodiscus spp.	188	222	801	1,790	119	870	733	699	7,485	7,928	801	9,088	30,724
Nitzschia spp.	750	1,790	205										2,745
Proboscia spp.	205			17	290		17						529
Pseudo-nitzschia spp.	1,586	818	904	154	921	136	136			51			4,706
Rhizosolenia spp.	597	870	171	34	136	17	51		4,331	4,075	1,279	2,933	14,494
Skeletonema spp.	477	1,074	222	938	119	51		375			921	1,807	5,984
Dinoflagellate													
Ceratium spp.	597	580	580	7,093	512	1,500	256	1,040	1,057	5,644	1,074	1,944	21,877
Dinophysis spp.		85		34			34	341		256			750
Protoperidinium spp.								495	716	580	836	307	2,934
Blue-Green Algae													
Oscillatoria spp.	921	6,360	2,200	392		102							9,975
Total	5,321	11,799	5,083	10,452	2,097	2,676	1,227	2,950	13,589	18,534	4,911	16,079	94,718

Table 5. Composition and density of phytoplankton in the coastal area of Brgy. Mangingisda. Harmful species (Lundholm et al. 2009 onwards) are written in bold.

Taxa	Density (Total number of phytoplankton cells L^{-1} of water filtered)												
	2018									2019			Total
	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	
Diatom													
Coscinodiscus spp.	614	853	23,069	1,398	614	1,228	136	563	546	409	597	136	30,163
Nitzschia spp.		102											102
Proboscia spp.	102			648			34						784
Pseudo-nitzschia spp.	34	17						136					187
Rhizosolenia spp.	68						409				1,023	1,177	2,677
Skeletonema spp.	102	68	256	256	818	460		392	375	307			3,034
Dinoflagellate													
Ceratium spp.	358	750	154	1,449	1,790	529	239	2,148		426	307	188	8,338
Dinophysis spp.					51	188							239
Prorocentrum sp.								171					171
Protoperidinium spp.	85	392		17	68	34	290	85					971
Blue- Green Algae													
Oscillatoria spp.							85						85
Total	1,363	2,182	23,479	3,768	3,341	2,439	1,193	3,495	921	1,142	1,927	1,501	46,751

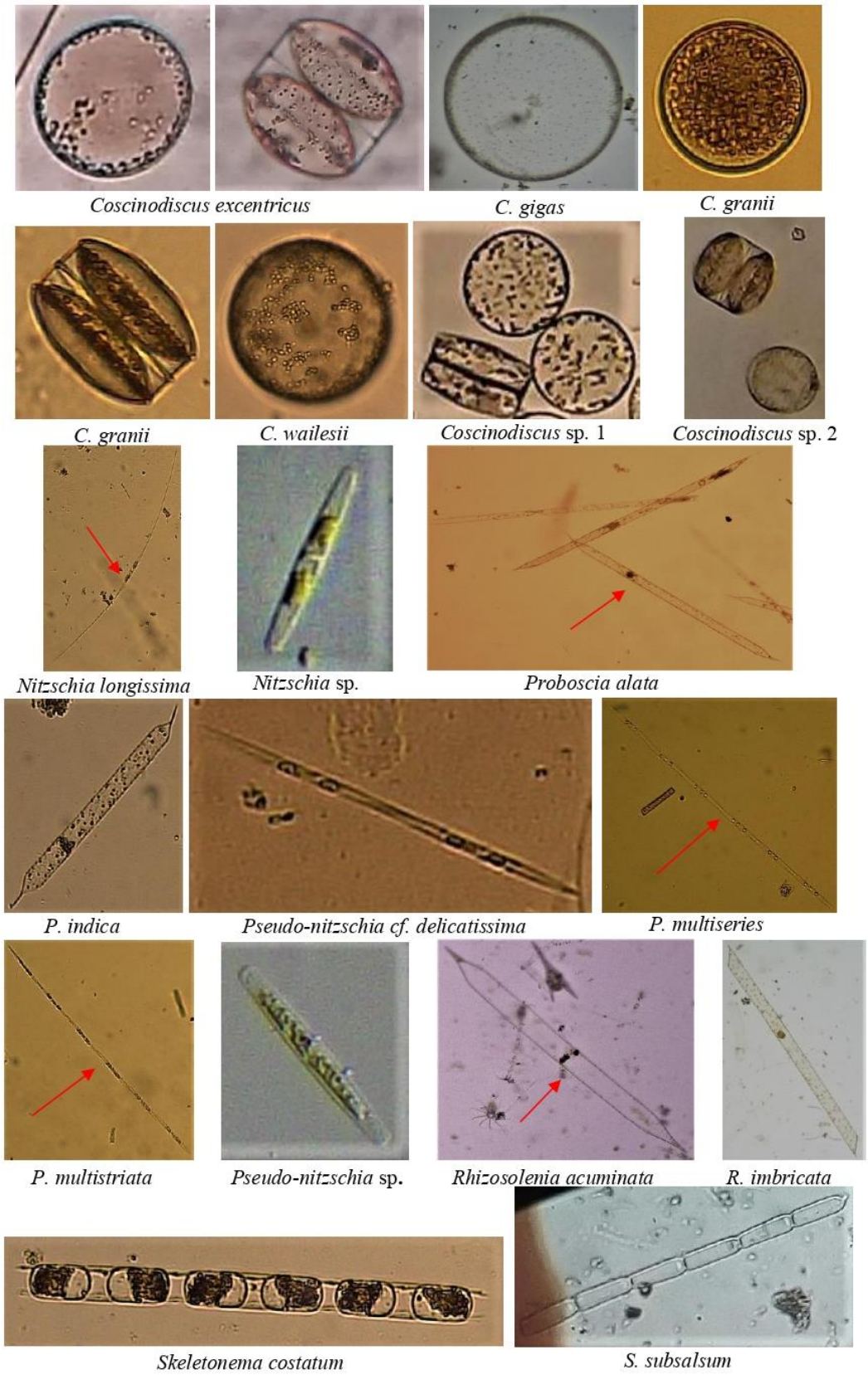

Figure 2. The diatoms species found in the coastal areas of Puerto Princesa Bay.

Figure 3. The dinoflagellate species found in the coastal areas of Puerto Princesa Bay.

Figure 4. The blue-green algae species found in the coastal areas of Puerto Princesa Bay.

Fecal Coliform

The highest fecal coliform count (> 1600 MPN/100 ml) was recorded in September 2018 in the coastal areas with the presence of informal settlers (Table 6). Moreover, this month gave the highest readings for all sampling sites. The lowest fecal coliform count (< 1.8 MPN/100 ml) was recorded in April 2018 in the two coastal areas without informal settlements, and again in Brgy. Mangingisda in January 2019.

Physicochemical Characteristics

The water temperatures in Puerto Princesa Bay ranged from 25.2 to 32.1ºC (Table 7). The mean temperature of water varies closely between the coastal areas with the presence and absence of informal settlers. The pH values ranged from 7.6 to 9.2. The highest observed pH was in Quito (April 2018) and the lowest in Brgy. Mangingisda (September 2018). The dissolved oxygen (DO) in the four coastal areas ranged from 3.2 to 6.8 mg L^{-1}. The mean DO values for both sites with the presence and absence of informal settlers do not vary much. The salinity ranged from 14.2 to 48.9 ppt, with the lowest value observed in Caña Island in December 2018 and the highest value measured in Quito in April 2018. The total dissolved solids (TDS) ranged from 8.2 to 24.2 ppt in the four sampling sites. The lowest TDS value was observed in Quito (November 2018) and the highest in Brgy. Mangingisda (April 2018).

Water Quality in Relation to the Presence of Informal Settlers

Kruskal-Wallis statistical analysis identified four phytoplankton genera which are significantly different in terms of their density between the coastal areas with the presence and absence of informal settlers at $P < 0.05$ (Table 8). These include *Pseudo-nitzschia*, *Skeletonema*, *Alexandrium*, and *Ceratium*. There is also a significant difference in the fecal coliform in the coastal areas with and without informal settlers. On the other hand, there is no significant difference observed in the physicochemical characteristics of the coastal areas with the presence and absence of informal settlers.

Regression analysis indicates that the presence of informal settlements in the coastal areas can affect both the fecal coliform and the composition and density of five phytoplankton genera - *Coscinodiscus*, *Pseudo-nitzschia*, *Skeletonema*, *Alexandrium*, and *Ceratium* (Table 9).

DISCUSSION

Phytoplankton Composition and Density

The five phytoplankton genera – *Nitzschia*, *Pseudo-nitzschia*, *Dinophysis*, *Alexandrium*, and *Pyrodinium* – present in the coastal areas with informal settlers are included in the IOC-UNESCO Taxonomic Reference List of Harmful Micro Algae (Lundholm et al. 2009 onwards). Incidentally, the first three genera were also observed in coastal areas without informal settlers. Both the diatom genera *Nitzschia* and *Pseudo-nitzschia* are capable of producing the neurotoxin domoic acid (DA), the causative agent of amnesic shellfish poisoning (ASP) (Sahraoui et al. 2011; Su et al. 2017). The toxin accumulates in shellfish and consumption of such results in intoxication including memory loss, disorientation, gastrointestinal and respiratory distress, and ataxia, which may lead to death via respiratory paralysis (Kadiri and Isagba 2018).

The remaining three HABs genera - *Dinophysis*, *Alexandrium*, and *Pyrodinium* - are dinoflagellates. Many *Dinophysis* species are capable of producing diarrhoetic toxins and pectenotoxins, the causative agents of diarrhetic shellfish poisoning (DSP). Gastrointestinal illness may occur immediately after consumption of contaminated shellfish, even at low cell densities (Reguera et al. 2014). On the other hand, several species of the genus *Alexandrium* and a single species of *Pyrodinium* (*P. bahamense*) can cause paralytic shellfish poisoning through the production of saxitoxin which accumulates in shellfish. Eating contaminated mollusks such as clams, oysters, and mussels can lead to various gastrointestinal and neurologic symptoms, which in extreme cases, is fatal (Band-Schmidt et al. 2019). Both *Alexandrium*, and *Pyrodinium* were only observed in coastal areas inhabited by informal communities.

Both the coastal areas with the presence and absence of informal settlers were found to have high densities of two diatom genera (*Coscinodiscu*s and *Rhizosolenia*) and a dinoflagellate genus (*Ceratium*). Although these phytoplankton are not included the IOC-UNESCO Taxonomic Reference List of Harmful Micro Algae (Lundholm et al. 2009 onwards), reports were found that these genera caused fish and shellfish mortalities. In Omani waters, blooms of *Coscinodiscus* species caused a massive fish kill (13,000 t0 27,000 kg of fish) in 2000 while *Ceratium* species triggered a mass mortality of marine organism in 1998 (Gheilani et al. 2011). In 1987, a bloom *Rhizosolenia chunii* in Port Phillip Bay, southeastern Australia, caused the mussels, scallops and flat oysters to develop an unpleasant and persistent bitter taste which eventually led to high shellfish mortality 3 to 8 months after the bloom had ended (Parry et al. 1989).

Table 6. Fecal coliform count of four coastal areas in Puerto Princesa Bay. Note: nd = no data due to unavailability of media and other reagents for fecal coliform analysis.

Sampling Site	Fecal Coliform (MPN/100 ml)											
	2018									2019		
	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Coastal areas with informal settlers												
Abanico	12.35	920	183.5	195	nd	>1600	1600	10.4	390	445	74.5	67.5
Quito	67.2	186.5	19	32.5	nd	>1600	6.4	19.5	30	4	185	17
Coastal areas without informal settlers												
Caña Island	<1.8	41	3.2	5.4	nd	295	5.6	7.8	6.2	71.8	4.9	10.8
Mangingisda	<1.8	8.8	1.9	1.9	nd	71	4.8	8.6	4.9	<1.8	22.5	110.9

Table 7. Physicochemical characteristics of four coastal areas in Puerto Princesa Bay.

Sampling Site	Physicochemical Parameters									
	Temperature (°C)		pH		DO (mg L^{-1})		Salinity (ppt)		TDS (g L^{-1})	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Coastal areas with informal settlers										
Quito	27.4-31.5	29.3	8.2-9.2	8.38	3.5-6.5	5.4	14.2-48.8	40.9	9.5-16.7	12.5
Abanico	28.0- 32.1	29.7	8.0-8.7	8.38	4.0-6.6	5.3	28.8-48.6	40.9	8.2-23.6	12.2
Coastal areas without informal settlers										
Caña Island	27.7-31.6	29.6	8.1-8.5	8.29	3.3-6.5	4.9	14.2-48.8	40.9	9.5-16.7	12.5
Mangingisda	25.2-31.2	28.3	7.6-8.8	8.44	3.2-6.8	5.1	28.9- 48.3	43.4	8.4-24.2	13.0

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Table 8. Significant difference between the water quality of four coastal areas in Puerto Princesa Bay with and without informal settlers. Note: ** significant at $P < 0.01$; * significant at $P < 0.05$.

Parameter	Kruskal-Wallis	
	Computed Value	Significant Value
Phytoplankton		
Diatoms		
Coscinodiscus spp.	1.616	0.204
Nitzschia spp.	2.185	0.139
Proboscia spp.	0.859	0.354
Pseudo-nitzschia spp.	7.694	0.006 **
Rhizosolenia spp.	0.006	0.940
Skeletonema spp.	6.912	0.009 **
Dinoflagellates		
Alexandrium spp.	4.265	0.039 *
Ceratium spp.	7.985	0.005 **
Dinophysis spp.	0.153	0.696
Prorocentrum sp.	0.001	0.976
Protoperidinium spp.	2.201	0.138
Pyrodinium sp.	0.000	1.000
Blue-Green Algae		
Oscillatoria spp.	0.207	0.649
Fecal Coliform	12.075	0.001 **
Physicochemical		
Temperature (ºC)	1.407	0.236
pH	0.254	0.614
DO (mg L^{-1})	1.358	0.244
Salinity (ppt)	0.011	0.918
TDS (g L^{-1})	0.310	0.578

Table 9. Water quality in relation to the presence of informal settlers in four coastal areas of Puerto Princesa Bay. Note: ** significant at $P < 0.01$; * significant at $P < 0.05$.

Parameter	Logistic Regression (df=1)	
	Statistical Value	Significant Value
Phytoplankton		
Diatoms		
Coscinodiscus spp.	4.092	0.043*
Nitzschia spp.	2.860	0.091
Proboscia spp.	0.690	0.406
Pseudo-nitzschia spp.	8.145	0.004 **
Rhizosolenia spp.	0.000	1.000
Skeletonema spp.	8.043	0.005 **
Dinoflagellates		
Alexandrium spp.	4.181	0.041*
Ceratium spp.	6.063	0.014 *
Dinophysis spp.	0.222	0.637
Prorocentrum sp.	0.080	0.777
Protoperidinium spp.	2.037	0.154
Pyrodinium sp.	-	-
Blue-Green Algae		
Oscillatoria spp.	0.315	0.575
Fecal Coliform	5.199	0.023 *
Physicochemical		
Temperature (ºC)	2.111	0.146
pH	0.006	0.940
DO (mg L^{-1})	1.003	0.317
Salinity (ppt)	0.193	0.660
TDS (g L^{-1})	0.094	0.760

The less abundant phytoplankton genera found in Puerto Princesa Bay include *Proboscia, Skeletonema, Prorocentrum, Protoperidinium,* and *Oscillatoria*. There were also reports that these genera produced either toxic or nontoxic blooms. One study showed that a bloom of the diatom *Proboscia alata* occurred in 2009 in the coastal sea off Bekal, India resulting in pale brown discoloration of water (Thomas et al. 2014). Another study showed that a dense bloom of diatoms *Skeletonema costatum* and *Thalassiosira* species in British Columbia, Canada resulted in gill lesions and mortality in Atlantic salmon reared in the area. This was the first report of fish kill caused by these diatoms (Kent et al. 1995). Moreover, studies showed that *Prorocentrum minimum* and *P. cordatum* cause mass aquaculture fish kills in Japan, Philippines and Singapore while *P. rhathymum* can cause DSP, similar with *Dinophysis* species (Yñiguez et al. 2021). In 2019, a brownish-red dense bloom of *Protoperidinium steinii* was observed in the tropical Indian waters, but did not cause mortality in marine organisms (Sathishkumar et al. 2021). Lastly, *Oscillatoria acutissima* was reported to have caused massive fish mortality in the Alexandrian waters in Egypt (Ismael 2012).

The months that exhibited the highest density of toxic and potentially toxic phytoplankton in Puerto Princesa Bay were June 2018 and January 2019. The next highest density of these phytoplankton was observed in July 2018, January 2019, and March 2019. Interestingly, the recorded incidences of red tide in Puerto Princesa Bay for the last three years occurred during these months (BFAR 2017, 2018, 2019, 2020; Puerto Princesa 2017) or close to these periods.

Fecal Coliform

The coastal areas with the absence of informal settlers passed the Philippine standard for Class SB waters in terms of fecal coliform, which is 100 MPN/100 ml (DENR 2016), throughout the sampling period with the exception of Caña Island in the month of September (295 MPN/100 ml) and Brgy. Mangingisda in the month of March (110.9 MPN/100 ml).

On the other hand, coastal areas with the presence of informal communities exceeded the limit of Philippine standard for Class SB waters for fecal coliform for most months, with the highest count at > 1600 MPN/100 ml. Only in the months of March, April, and November did these areas have fecal coliform counts within the limit set by DENR (2016). As previously stated, these sites have many houses built on stilt with residents that directly discharge human wastes on coastal areas.

The fecal coliform count was found to be highest (> 1600 MPN/100 ml) in September, during the rainy season and lowest (< 1.8 MPN/100 ml) in April, a dry season. These findings are parallel with Latha and Mohan (2013) that explained that the presence of fecal coliform bacteria in water indicates water pollution. These pathogenic microorganisms from human and animal wastes can contaminate fish and other marine organisms which in turn can pose serious health threat to human consumers, particularly in cases of extreme fecal contamination in seawater. Such situation can also affect the environmental quality and the over-all economy of the country (Echapare et al. 2019).

Physicochemical Characteristics

The average temperature in the four coastal areas is within (or close to) the limit set by the Philippine standard for Class SB waters, which is 26° to 30°C (DENR 2016). In addition, the temperature range (25.2 to 32.1 ºC) in the four coastal areas is good for phytoplankton growth which requires an optimum temperature ranging from 20° to 30ºC (Veronica et al. 2014). Similarly, the pH average values for all sampling sites (8.29 to 8.44) are within the permissible limits of the Philippine standard for Class SB waters, which is 7.0 to 8.5 (DENR 2016).

The average dissolved oxygen (4.9 to 5.4 mg L^{-1}) in the four coastal areas is below the permissible limits of the Philippine standard for Class SB waters, which is 6.0 mg L^{-1} (DENR 2016). Puerto Princesa Bay is a harbor for fishing and commercial boats. The water has domestics rubbish and oil spills from boats, in addition to untreated sewage and domestic waste from coastal communities surrounding the bay (Yap et al. 2011). According to Bozorg-Haddad et al. (2021), the introduction of organic wastes, such as domestic and animal sewage, can greatly reduce the DO in water. This is alarming since most aquatic organisms need oxygen to survive; in particular, fish cannot survive for long in water with DO < 5 mg L^{-1}. Thus, low DO in water is a sign of contamination. In addition, Seo et al. (2019) explained that DO and pH have a negative relationship with fecal coliform. The proliferation of coliform bacteria leads to consumption of DO and the production of carbon dioxide results in a decrease in pH.

The Philippine standards for water quality did not set a limit for both salinity and total dissolved solids in coastal waters (DENR 2016). The wide range of salinity (14.2 to 48.9 ppt) in the four coastal areas may be due to freshwater runoff during rainy season resulting in low salinity and high evaporation rate near shallow areas during summer leading to high salinity (AMSAT 2008). On the other hand, the total dissolved solids in the coastal waters may have come from agricultural runoff and leaching of soil contaminants (Yap et al. 2011).

Water Quality in Relation to the Presence of Informal Settlers

Two water quality parameters showed significant difference at $P < 0.05$ between the coastal areas with and without informal settlers. These include fecal coliform and the density of the four phytoplankton genera – *Pseudo-nitzschia*, *Skeletonema*, *Alexandrium*, and *Ceratium*. In addition, the positive statistical values in Kruskal-Wallis indicate that the density of all phytoplankton genera is higher in the coastal areas with the presence of informal settlers, but the difference is not significant in some phytoplankton. Likewise, there is no significant difference in the physicochemical parameters between the coastal areas with the presence and absence of informal settlers.

In regression analysis, the higher the statistical value and the lower the significant value ($P < 0.05$), the higher is the tendency for a particular parameter to be affected by the presence of informal settlement in the coastal areas. The parameters that could be affected by the presence of informal settlers in coastal areas include fecal coliform and the five phytoplankton genera (*Coscinodiscus*, *Pseudo-nitzschia*, *Skeletonema*, *Alexandrium* and *Ceratium*) which are all significant at $P < 0.05$. It can be deduced from the result of linear regression that these five phytoplankton genera will thrive in water contaminated with fecal coliform.

Based on the results of this study and in light of the recurring incidence of red tide in Puerto Princesa Bay, it is highly recommended that the local government should provide policies for the management of human-caused sources of pathogenic bacteria, to keep the fecal contamination within a range considered safe for human health and to prevent its contribution to harmful or potentially harmful algal blooms. Relocation programs of the local government unit may be strengthened and information campaigns may be organized to increase the awareness of the local residents on the impacts of informal settlements on the water quality of Puerto Princesa Bay.

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ROLE OF AUTHORS: *RCG – developed the concept, conducted the experiments, collected and analyzed data, drafted, reviewed, revised and finalized the manuscript; LSJ – co-developed the concept, assisted in conducting the experiments, collecting, and analyzing the data, helped in writing and reviewing the manuscript; SIW – co-developed the concept, assisted in analyzing the data, performed statistical treatment and interpretation of results.*

Guide for Authors

The Palawan Scientist, a recipient of the CHED's Journal Incubation Grant, is a bi-annual peer-reviewed multi-disciplinary journal published by the Western Philippines University, with its main campus in Aborlan, Palawan, Philippines. It accepts original research papers, reviews, notes and short communications in agriculture, fisheries and aquatic sciences, environment, education, engineering, mathematics, sociology and other discipline.

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    Dolorosa RG, Grant A and Gill JA. 2013. Translocation of wild *Trochus niloticus*: prospects for enhancing depleted Philippine reefs. Reviews in Fisheries Science, 21(3-4): 403-413. DOI: 10. 1080/ 10641262. 2013. 800773.

    Jontila JBS, Balisco RAT and Matillano JA. 2014. The sea cucumbers (Holothuroidea) of Palawan, Philippines. AACL Bioflux, 7(3): 194-206. http://www.bioflux.com.ro/docs/2014.194-206.pdf

8. Citing of books – name(s) of author(s), year of publication, full title of the Book (capitalize each main word), publisher, place of publication and total number of pages.

    Gonzales, BJ. 2013. Field Guide to Coastal Fishes of Palawan. Coral Triangle Initiative on Corals, Fisheries and Food Security, Quezon City, Philippines. 208pp.

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    Poutiers JM. 1998. Gastropods. In: Carpenter KE and Niem VH (eds). FAO Species Identification Guide for Fishery Purposes. The Living Marine Resources of the Western Central Pacific Seaweeds, Corals, Bivalves and Gastropods. Food and Agriculture Organization, Rome, pp. 364-686.

10. Citing a Webpage – names of the author (s), year, Title of the article, webpage address and date accessed.

    Morrison H and Pfuetzner S. 2011. Australia Shells. http://www.seashells.net.au/Lists/ TEREBRIDAE. html. Accessed on 4 September 2011.

CITES (Convention on International Trade of Endangered Species). 2014. The CITES Appendices. Convention on International Trade in Endangered Species of Wild Flora and Fauna. www.cites.org. Accessed on 05 January 2014.

11. Citing a thesis or dissertation – author's family name, initial names of the author, year, title of the thesis, degree, name of institution, address of the institution, total number of pages (pp).

Guion SL. 2006. Captive breeding performance of *Crocodylus porosus* (Schneider 1901) breeders at the Palawan Wildlife Rescue and Conservation Center. BS in Fisheries. Western Philippines University-Puerto Princesa Campus, Palawan, Philippines. 28pp.

Lerom RR. 2008. Biosystematics study of Palawan landraces of rice (*Oryza sativa* L.). Doctor of Philosophy, Institute of Biological Sciences, University of the Philippines-Los Baños College, Laguna, Philippines. 197pp.

12. Citing a Report

Picardal RM and Dolorosa RG. 2014. Gastropods and bivalves of Tubbataha Reefs Natural Park, Cagayancillo, Palawan, Philippines. Tubbataha Management Office and Western Philippines University. 25pp.

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Alcantara LB and Noro T. In press. Growth of the abalone *Haliotis diversicolor* (Reeve) fed with macroalgae in floating net cage and plastic tank. Aquaculture Research.

14. Citing an article from an online newspaper.

Cuyos JM. 2011. Endangered deep-sea shells seized from Mandaue firm. Inquirer Global Nation, Cebu. http://globalnation.inquirer.net/ cebudailynews/news/view/20110325-327558/Endangered-deep-sea-shells-seized-from-Mandaue-firm. Accessed on 31 May 2012.

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