DISTRIBUTION, VIRULENCE FACTORS AND ANTIMICROBIAL RESISTANCE OF *Vibrio* SPECIES ISOLATED FROM CULTURED SHRIMP IN PENINSULAR MALAYSIA

By

WAN HAIFA HARYANI BINTI WAN OMAR

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Doctor Philosophy

January 2024

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

DISTRIBUTION, VIRULENCE FACTORS AND ANTIMICROBIAL RESISTANCE OF *Vibrio* SPECIES ISOLATED FROM CULTURED SHRIMP IN PENINSULAR MALAYSIA

By

WAN HAIFA HARYANI BINTI WAN OMAR

January 2024

Chairman : Ina Salwany Md Yasin, PhD
Institute : Bioscience

Vibrio, the most common bacterium associated with crustacean diseases, poses a significant threat to shrimp farming due to outbreaks of vibriosis. Therefore, the study aims to provide a comprehensive database on the distribution of *Vibrio* spp. as well as virulence genes and antimicrobial resistance profiling in Malaysian shrimp farms. Briefly, a total of 210 cultured shrimp were collected from seven farms in Peninsular Malaysia. The findings revealed that 225 presumptive *Vibrio* isolates were isolated from cultured shrimp which were then subjected to biochemical test and molecular detection using *pyrH* gene analysis. Eventually, 13 different *Vibrio* spp. were successfully isolated and characterized including *Vibrio parahaemolyticus* (55%), *V. communis* (9%), *V. campbellii* (8%), *V. owensii* (7%), *V. rotiferianus* (5%), *Vibrio* spp. (4%), *V. alginolyticus* (3%), *V. brasiliensis* (2%), *V. natriegens* (2%), *V. xuii* (1%), *V. harveyi* (1%), *V. hepatarius* (0.4%) and *P. damselae* (3%). Based on virulence genes assessment, eight of the eleven

virulence genes in this study were detected, including *chiA* (89%), *flaC* (74%), *tlh* (72%), *toxR* (70%), *luxR* (40%), *pirA* (11%), *pirB* (11%) and *hlyA* (0.4%). Other virulence genes, such as *tdh*, *trh* and *ctxA*, were not detected in any isolates (0%). From the virulence gene assessment, three *Vibrio* isolates were chosen for the pathogenicity test based on highest number present in each of the species. The isolates including *V. parahaemolyticus* S12-3, *V. campbellii* S10-4, and *V. rotiferianus* S24-4 were tested by immersion challenge test against postlarvae (PL) *Penaeus monodon* approximately PL-20 with three different concentrations of 1×10^6 CFU/mL, 1×10^7 CFU/mL, and 1×10^8 CFU/mL. The LC_{50} result revealed that the lowest were *V. parahaemolyticus* S12-3 (1×10^5 CFU/mL) followed by *V. rotiferianus* S24-4 (1×10^{11} CFU/mL) and *V. campbellii* S10-4 (1×10^{13} CFU/mL). Moreover, histopathological analysis showed sloughing of epithelial cells in hepatopancreatic tubule, haemocytic infiltration, massive vacuolation and loss of hepatopancreatic tubule structure. Meanwhile, the majority of the species tested were resistant to penicillin G (100%), but susceptible to norfloxacin (96%). According to the multiple antibiotic resistance (MAR) index, 84% of *Vibrio* spp. exhibited a MAR index value of more than 0.2. Thus, the findings suggested that a large number of *Vibrio* spp. were resistant to several antibiotics and had been exposed to antibiotics on a regular basis at the farms. Plasmid profiling revealed that 125 isolates from a total 225 of *Vibrio* isolates harboured plasmid with the size ranging from 1 kb and above 10 kb, separating the isolates into 23 plasmid profiles. After plasmid curing, *Vibrio*-positive plasmid was lost resistance to antibiotics. The findings revealed that the resistance to antibiotics in isolated *Vibrio* spp. were either chromosomal or plasmid mediated. In conclusion, ongoing monitoring of antibiotic-resistant microorganisms as well as understanding the genetic basis of resistance are essential to implement a strategy for minimizing AMR strain yet to improve shrimp farming management in Malaysia.

Keywords: Antimicrobial resistance, Peninsular Malaysia, shrimp, *Vibrio* spp., virulence

SDG: GOAL 4: Quality Education

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

TABURAN, FAKTOR VIRULEN DAN KERINTANGAN ANTIMIKROB TERHADAP SPESIES *Vibrio* YANG DIPENCILKAN DARIPADA TERNAKAN UDANG DI SEMENANJUNG MALAYSIA

Oleh

WAN HAIFA HARYANI BINTI WAN OMAR

Januari 2024

Pengerusi : Ina Salwany Md Yasin, PhD
Institut : Biosains

Vibrio adalah bakteria yang paling kerap dikaitkan dengan penyakit pada krustasea yang akhirnya memberikan ancaman yang serius terhadap penternakan udang disebabkan oleh wabak vibriosis. Oleh itu, kajian ini dijalankan bertujuan untuk menyediakan pangkalan data komprehensif mengenai taburan spesies *Vibrio*, gen virulensi dan profil kerintangan antibiotik terhadap spesies *Vibrio* yang dipencilkan daripada ternakan udang di Semenanjung Malaysia. Secara ringkasnya, sebanyak 210 ekor ternakan udang dari tujuh ladang yang terletak di kawasan geografi yang berbeza di Semenanjung Malaysia. Hasil penemuan menunjukkan sebanyak 225 spesies *Vibrio* telah berjaya dipencilkan daripada ternakan udang yang kemudiannya disaring dengan ujian biokimia dan pengesanan molecular berdasarkan gen *pyrH*. Melalui pengesanan molekular menggunakan gen *pyrH*, sebanyak 13 spesies *Vibrio* telah dipencilkan dan dicirikan iaitu *Vibrio parahaemolyticus* (55%), *V. communis* (9%), *V. campbellii* (8%), *V. owensii* (7%), *V. rotiferianus* (5%), *Vibrio* spp. (4%), *V. alginolyticus* (3%), *V.*

brasiliensis (2%), *V. natriegens* (2%), *V. xuii* (1%), *V. harveyi* (1%), *V. hepatarius* (0.4%) dan *P. damselae* (3%). Kesemua isolat daripada spesies *Vibrio* kemudiannya disaring untuk gen virulensi di mana lapan daripada 11 gen virulensi dikesan termasuk *pirA* (11%), *pirB* (11%), (72%), *flaC* (74%), *toxR* (70%), *chiA* (89%), *luxR* (40%) dan *hlyA* (0.4%). Gen virulensi yang lain seperti *tdh, trh*, dan *ctxA* tidak ditemui dalam mana-mana isolate (0%). Daripada pencirian virulensi, sebanyak tiga spesies *Vibrio* telah dipilih untuk ujian patogenisiti berdasarkan bilangan gen virulensi tertinggi yang terdapat dalam setiap isolat. Isolat yang terdiri daripada *V. parahaemolyticus* S12-3, *V. campbellii* S10-4, dan *V. rotiferianus* S24-4 telah diuji dengan kaedah infeksi secara rendaman terhadap benih udang *Penaeus monodon* (PL-20) dengan tiga kepekatan yang berbeza iaitu 1×10^6 CFU/mL, 1×10^7 CFU/mL dan 1×10^8 CFU/mL. Keputusan LC_{50} menunjukkan bacaan yang paling rendah ialah *V. parahaemolyticus* S12-3 (1×10^5 CFU/mL) diikuti oleh *V. rotiferianus* S24-4 (1×10^{11} CFU/mL) dan *V. campbellii* S10-4 (1×10^{13} CFU/mL). Analisis histopatologi pula menunjukkan terdapat penyusutan sel epitelium dalam tubul hepatopankreatik, penyusupan hemositik, pembesaran pada vakuolasi dan kehilangan struktur tubul hepatopankreatik. Sementara itu, kesemua isolat bersifat rintang terhadap penisilin G (100%), tetapi rentan terhadap norfloxacin (96%). Tambahan pula, 84% daripada isolat menunjukkan indeks kerentanan antibiotik berbilang (MAR) lebih daripada 0.2. Manakala 16% menunjukkan indeks kerentanan antibiotik berbilang (MAR) kurang daripada 0.2. Pemprofilan plasmid mendedahkan sebanyak 125 isolat daripada jumlah 225 isolat yang mengandungi plasmid dengan saiz plasmid di antara 1 kb dan lebih daripada 10 kb, yang memisahkan sebanyak 23 profil plasmid. Semasa proses pemulihan

plasmid, kebanyakan *Vibrio*-positif plasmid telah kehilangan kerentanan terhadap antibiotik. Hasil penemuan mendapati isolat yang rentan terhadap antibiotik ini mungkin disebabkan oleh mediasi-kromosom atau mediasi-plasmid. Secara kesimpulannya, pemantauan yang berterusan terhadap mikroorganisma rintang antibiotik serta pemahaman asas genetik rintangan adalah penting untuk melaksanakan strategi meminimumkan strain AMR dan pada masa yang sama meningkatkan pengurusan ternakan udang di Malaysia.

Kata Kunci: Kerintangan antimikrob, Semenanjung Malaysia, spesies *Vibrio*, udang, virulen

SDG: MATLAMAT 4: Kualiti Pendidikan

ACKNOWLEDGEMENTS

Assalamualaikum W.B.T. and Alhamdulillah.

In the first place, a huge thanks to my supervisor Assoc. Prof. Dr. Ina Salwany Md Yasin for her guidance, motivation, inspiration and patiently support in my study. An appreciation also goes to my co-supervisors, Prof. Dr. Mohd Zamri Saad, Assoc. Prof. Dr. Mohammad Noor Amal Azmai and Assoc Prof. Dr. Natrah Fatin binti Mohd Ikhsan for their support and advice.

My deepest gratitude always goes to my husband, Mohd Hafiz Mohd Zainal, my independent and lovely daughters, Hanan Husna and Hana Haura, my parents Wan Omar bin Wan Ab Ghani and Hamidah Omar, my mother-in-law, Rogayah Senek and my siblings. No words can be written to picture their endless love, motivation, emotional and support, and prayers throughout the whole study. Without their support and caring, I would not be able to pass through the hardest time during this challenging PhD journey. Thank you again for being supportive and encourage me to complete my PhD.

Extended my gratitude to all my fellow laboratory mates, especially to Amatul, Shidaa, Izyan, Chin, Azzam, Amir, Aslah, Sofie, Lee, Syafiq, Monir and other students and academic staffs of the Aquatic Animal Health and Therapeutics Laboratory, Institute of Bioscience and Biotechnology Aquaculture Laboratory, Faculty of Aquaculture, Universiti Putra Malaysia for their tremendous support and endless motivation. I do appreciate all your help.

This research was financially funded by International Development Research Center (IDRC), Canada and Global AMR Innovation fund (GAMRIF), United Kingdom under the INNOVET-AMR Grant (Project number: 109055). The facilities supported by Higher Institution Centre of Excellence (HICoE) (Animal Vaccines and Therapeutics) by the Ministry of Education (MOE), Malaysia. A huge thank also goes to Universiti Putra Malaysia for providing me the SGRA to support my study.

Thank you very much.

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

Ina Salwany binti Md Yasin, PhD
Associate Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Chairman)

Natrah Fatin binti Mohd Ikhsan, PhD
Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Member)

Mohammad Noor Amal bin Azmai, PhD
Professor
Faculty of Science
Universiti Putra Malaysia
(Member)

Mohd Zamri bin Saad, PhD
Professor
Faculty of Veterinary Medicine
Universiti Putra Malaysia
(Member)

____
ZALILAH MOHD SHARIFF, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 13 June 2024

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

α	alpha
β	beta
°C	degree celsius
%	percentage
µL	microliter
µm	micrometre
µM	micromolar
AMP	ampicillin
AMR	antimicrobial resistance
AO	acridine orange
ARG	antimicrobial resistance genes
BLASTn	nucleotide basic local alignment search tool
bp	base pair
C	chloramphenicol
$CaCl_2$	calcium chloride
CAZ	ceftazidime
CFU/mL	colony forming units per millilitre
chiA	chitinase a
CIP	ciprofloxacin
CN	gentamicin
CTX	cefotaxime
ctxA	cholera toxin
DNA	deoxyribonucleic acid
dNTP	deoxynucleotide triphosphate
DO	dissolved oxygen
DOF	Department of Fisheries
E	erythromycin
EB	ethidium bromide
F	nitrofurantoin
FAO	Food and Agriculture Organization of the United Nations

FDA	Food and Drug Administration
FEP	cefepime
fla	flagella
g	gram
g/L	gram per litre
H&E	haematoxylin and eosin
HGT	horizontal gene transfer
hly	hemolysin
IACUC	Institutional Animal Care and Use Committee
K	kanamycin
kb	kilobase
KF	cephalothin
kg	kilogram
L	litre
LC_{50}	lethal concentration of 50
LDC	lysine decarboxylase
LPS	lipopolysaccharide
luxR	transcriptional activator protein
M	molar
MAR	multiple antibiotic resistance
mg	milligram
mL	millilitre
$MgCl_2$	magnesium chloride
MHA	Muller-Hinton agar
ML	Maximum Likelihood
mM	millimolar
MT	metric tonnes
Na_2HPO_4	sodium hydrogen phosphate
NaCl	sodium chloride
NaH_2PO_4	sodium dihydrogen phosphate
NOR	norfloxacin
OMP	outer membrane protein
ONPG	ortho-nitrophenyl-β-galactoside

P	penicillin G
PBPs	penicillin-binding proteins
PCR	polymerase chain reaction
pirA/pirB	photorhabdus insect-related toxin
pyrH	uridylate kinase
ppt	part per thousand
qPCR	quantitative polymerase chain reaction
RNA	ribonucleic acid
rpm	revolutions per minute
rRNA	ribosomal ribonucleic acid
SD	standard deviation
SDS	sodium dodecyl sulfate
spp.	species
SXT	sulfomethiozole-trimethoprim
TAE	tris-acetic EDTA
TCBS	thiosulfate citrate bile salts sucrose
tdh	thermostable direct hemolysin
TET	tetracycline
tlh	thermolabile hemolysin
toxR	trancriptional regulatory protein
trh	thermostable direct hemolysin
tRNA	transfer ribonucleic acid
TSA	tryptic soy agar
TSB	tryptic soy broth
TSI	triple sugar iron
U/mL	units per millilitre
UV	ultra violet
V	voltan
v/v	volume per volume
VA	vancomycin

CHAPTER 1

INTRODUCTION

1.1 Background of the study

Aquaculture is one of the fastest growing industries in the world. According to FAO (2022), marine shrimp was among the highest demand in aquaculture, approximately USD 34.2 billion accounting for 5.51 metric tonnes (MT) followed by freshwater crustaceans at USD 24.3 billion accounting for 2.53 MT. However, the shrimp industry faces numerous challenges such as disease outbreak caused by bacterial, viruses and fungal diseases in the aquaculture system (El- Saadony et al., 2022).

Vibriosis caused by *Vibrio* spp. has gained attention as a causative agent of diseases in aquatic animals, and it is recognised as significant contributor to the diseases with huge economic impacts on global aquaculture industry including shrimp aquaculture industry (Hossain et al., 2024). This *Vibrio*-related disease causes significant losses in yield and causing substantial economic damage every year (Li et al., 2020). In order to solve the problem, antibiotics are commonly used to promote growth, prevent and treat bacterial infections. However, the widespread and inappropriate usage of antibiotics are leading for emergence and spread of antimicrobial resistance (AMR). This alarming issue threatens public health by diminishing the effectiveness of antibiotics in treating diseases (Tang et al., 2023).

In addition, the presence or absence of virulence factors can influence how severe an infection is and how easily it can be treated (Li et al., 2019). There is some evidence to suggest that certain mechanisms of AMR can also contribute to the virulence. This means that when the bacteria become resistant to antibiotics, it may also increase virulency (De Nies et al., 2021). Some bacteria may acquire resistance genes on mobile genetic elements such as plasmid, that also carry genes involved in virulence (Dionisio et al., 2019). The plasmid plays a crucial role in facilitating the transfer of antibiotic-resistant genes, which can be transmitted to the next generation via vertical gene transfer or exchanged with other bacteria via horizontal gene transfer (Liu et al., 2022).

Overall, the surveillance of antimicrobial resistance and monitoring of antibiotic use in aquaculture should be encouraged to improve antibiotics management. In addition, aquaculture producers must adhere to the regulations and guidelines set by their local governments to minimize the risk of antibiotic resistance. Furthermore, it is also important to develop alternative methods for preventing and controlling disease to eliminate shrimp health risks.

1.2 Problem statements

Although there were several studies related to distribution, virulence and antimicrobial resistance on *Vibrio* spp. isolated from shrimp across the world, however in Malaysia, there were limited information regarding on these studies. In fact, if it covered *Vibrio* spp., it was just one or two species, and some of the studies only covered a limited number of geographical areas.

Therefore, the epidemiology of vibriosis in shrimp Malaysia's aquaculture remains poorly understood.

According to Lulijwa et al. (2020), there is a lack of data and information on antibiotic use in Malaysia. This causes difficulty in making an accurate comparison with other studies. Moreover, the research revealed that only 5.9% studies on antibiotic resistance in aquaculture and associated environments have been performed. The species involved were catfish (*Clarias gariepinus*), tilapia (*Tilapia mossambica*), banana prawn (*Penaeus indicus*), red prawn (*Solenocera subnuda*), groupers (Epinephelus spp.), Asian seabass (*Lates calcarifer*) and red snapper (*Lutjanus* sp.) (Budiati et al., 2013; Kathleen et al. 2016; Laith et al. 2017; Letchumanan et al. 2019; Amalina et al., 2019; Mohamad et al., 2019). With increasing concern over AMR, a threat to both aquaculture industries and public health, it is critical to monitor and prevent AMR among *Vibrio* species.

In addition, the virulence factors associated with *Vibrio* spp. pathogenicity in Malaysian cultured shrimp are yet unknown. As a result, some knowledge on the distribution and expression of virulence genes in *Vibrio* spp. might provide essential insights into environmentally friendly techniques to treating *Vibrio* infection in shrimp farming. Thus, a better understanding of vibriosis epidemiology will allow for the development of more effective curative and preventative methods to fight the disease.

1.3 Significance of study

In Malaysia, there is currently limited documentation regarding the presence of *Vibrio* spp. in cultured shrimp. Therefore, by investigating the distribution, virulence factors and antimicrobial resistance of *Vibrio* spp. in cultured shrimp, the valuable information for shrimp farmers, aquaculture researchers, and policymakers will be provided. In addition, the knowledge of the prevalence and distribution of diseases may assist farmers, researchers, and policymakers in the development of control measures for diseases in shrimp farming.

Moreover, the information is useful for regulations to control practices on the farms and minimize the magnitude of the antibiotic resistance among *Vibrio* spp. For this reason, information regarding on distribution of *Vibrio* spp. in the farms around Peninsular Malaysia particularly was important in order to provide greater knowledge of the epidemiology of *Vibrio* infection throughout a geographical region. The findings can contribute to the development of effective management strategies to mitigate the risk of disease outbreaks and promote sustainable shrimp farming practices in Peninsular Malaysia.

1.4 Objectives of the study

The research framework of the study was summarized in Figure 1.1. The study was carried out with the following objectives:

1. To isolate and characterize of *Vibrio* spp. from cultured shrimp collected from various geographical region in Peninsular Malaysia.

2. To assess virulence genes profiles of *Vibrio* spp. isolated from cultured shrimp in Peninsular Malaysia.
3. To evaluate the most virulent strain of isolated *Vibrio* spp. by experimental infection study in shrimp.
4. To determine the distribution and patterns of antimicrobial resistance in *Vibrio* spp. isolated from cultured shrimp in Peninsular Malaysia and their ability to transfer the resistance plasmid.

	Distribution, virulence factors and antimicrobial resistance of *Vibrio* species isolated from cultured shrimp in Peninsular Malaysia		
	Experimental Chapter 3	Experimental Chapter 4	Experimental Chapter 5
Objective	To isolate and characterize of *Vibrio* spp. from cultured shrimp collected from various geographical region in Peninsular Malaysia	To assess virulence genes profiles of *Vibrio* spp. isolated from cultured shrimp in Peninsular Malaysia and evaluate the most virulent strain of isolated *Vibrio* spp. by experimental infection study in shrimp.	To determine the distribution and patterns of antimicrobial resistance in *Vibrio* spp. isolated from cultured shrimp in Peninsular Malaysia and their ability to transfer the resistance plasmid.
Experiment	• Shrimp sampling from seven selected farms in Peninsular Malaysia • Biochemical test and Gram staining • Molecular identification using *pyrH* gene.	• Virulence-related gene profiling analysis • Challenge experiment • Histopathology analysis	• Antibiotic profiling • Plasmid profiling and curing
Output	Distribution of *Vibrio* spp. in selected shrimp farms in Malaysia were identified.	The multiple of virulence genes, percentage of mortality and histology changes of *Vibrio* spp. were determined.	Antibiotics and plasmid profiling were determined.
Outcome	The data provided will help to enhance the understanding of bacterial pathogens' dynamic in shrimp farming and develop target approaches to mitigate the risk of disease outbreak in shrimp farming.		

Figure 1.1: Research framework of this study based on the objectives throughout Chapter 3, 4 and 5. The other chapters included in this study were Chapter 1, Chapter 2 and Chapter 6.

1.5 Hypotheses of the study

The hypotheses of this study are as below:

Hypothesis 1:

Ho: The *Vibrio* spp. was not present in the cultured shrimp from the selected farms in Peninsular Malaysia.

H_1: The *Vibrio* spp. was present in the cultured shrimp from the selected farms in Peninsular Malaysia.

Hypothesis 2:

H_0: There are no difference in the presence of virulence gene profiling of *Vibrio* spp. isolated from cultured shrimp in Peninsular Malaysia.

H_1: There are difference in the presence of virulence gene profiling of *Vibrio* spp. isolated from cultured shrimp in Peninsular Malaysia.

Hypothesis 3:

H_0: There are no difference in the pathogenicity of selected *Vibrio* spp. as determined by the experimental infection study.

H_1: There are difference in the pathogenicity of selected *Vibrio* spp. as determined by the experimental infection study.

Hypothesis 4:

H_0: There are no difference in the presence of antibiotic resistance and plasmid profiling of *Vibrio* spp. isolated from cultured shrimp in Peninsular Malaysia.

H_1: There are difference in the presence of antibiotic resistance and plasmid profiling of *Vibrio* spp. isolated from cultured shrimp in Peninsular Malaysia.

REFERENCES

Abd-Elghany, S.M. and Sallam, K.I. (2013). Occurrence and molecular identification of *Vibrio parahaemolyticus* in retail shellfish in Mansoura, Egypt. *Food Control* 33: 399–405.

Abdullah, H. M., Ahmed, S. M., Khan, B. M., Mohana, N. T., Ahamed, T. and Islam, I. (2021). Agriculture and fisheries production in a regional blending and dynamic fresh and saline water systems in the coastal area of Bangladesh. *Environmental Challenges 4*: 100089.

Adeyemo, S. M. and Onilude, A. A. (2015). Plasmid curing and its effect on the growth and physiological characteristics of *Lactobacillus plantarum* isolated from fermented cereals. *J Microbiol Res*. *5*(1): 11-22.

Ahmed, O. and Amin, H. (2018). Detection and survival of *vibrio* species in shrimp (*Penaeus indicus*) and mussel (*Mytilus galloprovincialis*) at landing and after processing at seafood markets in Suez, Egypt. Journal of Food and Dairy*, Sciences* 9(12): 411-417.

Alam, S. N. (2024). Portraying the Bangladesh Shrimp Industry: A SWOT Analysis. Sustainability*,* 16(3): 1290.

Albuquerque Costa, R. A., Araujo, R. L., Souza, O. V., and Viera, R. H. S. F. (2015). Antibiotic-resistant vibrios in farmed shrimp. Biomed. Res. Int., 2015: 505914.

Alfaro, A.C., Nguyen, T.V., Rodríguez, J.A., Bayot, B., Domínguez-Borbor, C., Sonnenholzner, S., Azizan, A. and Venter, L. (2022). Evaluation of immune stimulatory products for whiteleg shrimp (*Penaeus vannamei*) by a metabolomics approach. Fish & Shellfish Immunology, 120: 421-428.

Alizadeh, J., Ranjbar, R., Kamali, M., Farhadi, N., Davari, A. and Sadeghifard, N. (2013). Cloning of *Vibrio cholerae* outer membrane protein W in Pichia pastoris. Iran J Microbiol., 5(3): 252.

Al-Othrubi, S. M. Y., Kqueen, C. Y., Mirhosseini, H., Hadi, Y. A. and Radu, S. (2014). Antibiotic resistance of *Vibrio parahaemolyticus* isolated from cockles and shrimp sea food marketed in Selangor, Malaysia. Clin Microbiol., 3: 148.

Amalina, N.Z., Santha, S., Zulperi, D., Amal, M.N.A., Yusof, M.T., Zamri-Saad, M. and Ina-Salwany, M.Y. (2019). Prevalence, antimicrobial susceptibility and plasmid profiling of *Vibrio* spp. isolated from cultured groupers in Peninsular Malaysia. BMC Microbiol., 19: 251.

Amatul-Samahah, M. A., Muthukrishnan, S., Omar, W. H. H. W., Ikhsan, N. F. M., Ina-Salwany, M. Y. (2020). *Vibrio* sp. associated with acute hepatopancreatic necrosis disease (AHPND) found in penaeid shrimp pond from east cost of Peninsular Malaysia. Journal of Environmental Biology, 41: 1160-1170.

Andrade, T. P., Cruz-Flores, R., Mai, H. N., & Dhar, A. K. (2022). Novel infectious myonecrosis virus (IMNV) variant is associated with recent disease outbreaks in P*enaeus vannamei* shrimp in Brazil. Aquaculture, 554: 738159.

Angthong, P., Uengwetwanit, T., Arayamethakorn, S., Chaitongsakul, P., Karoonuthaisiri, N. and Rungrassamee, W. (2020). Bacterial analysis in the early developmental stages of the black tiger shrimp (P*enaeus monodon*). Scientific reports, 10(1): 4896.

Araujo, G. S., Silva, J. W. A. D., Cotas, J. and Pereira, L. (2022). Fish farming techniques: Current situation and trends. Journal of Marine Science and Engineering, 10(11): 1598.

Asche, F., Anderson, J. L., Botta, R., Kumar, G., Abrahamsen, E. B., Nguyen, L. T., & Valderrama, D. (2021). The economics of shrimp disease. Journal of invertebrate pathology, 186: 107397.

Asgarpoor, D., Haghi, F. and Zeighami, H. (2018). Detection and Molecular Characterization of *Vibrio Parahaemolyticus* in Shrimp Samples. The Open Biotechnology Journal, 12: 46-50.

Atala, M. L. (2020). A Review Article: Bacterial Plasmids. JournalNX, 6(12):8-12.

Atwill, E. R. and Jeamsripong, S. (2021). Bacterial diversity and potential risk factors associated with Salmonella contamination of seafood products sold in retail markets in Bangkok, Thailand. *PeerJ.* 9: e12694.

Bai, F., Pang, L., Qi, Z., Chen, J., Austin, B. and Zhang, X. H. (2008). Distribution of five *Vibrio* virulence-related genes among *Vibrio harveyi* isolates. J Gen Appl Microbiol*.,* 54(1): 71-78.

Baker-Austin, C., Trinanes, J. A. and Taylor, N. G. H. (2012). Emerging *Vibrio* risk at high latitudes in response to ocean warming. Nature Climate Change, 3(1): 73-77.

Baker-Austin, C., Trinanes, J. and Martinez-Urtaza, J. (2020). The new tools revolutionizing *Vibrio* science. Environ. Microbiol., 22: 4096–4100.

Baker-Austin, C., Trinanes, J.A., Taylor, N.G.H., Hartnell, R., Siitonen, A. and Martinez-Urtaza, J. (2018). Emerging *Vibrio* risk at high latitudes in response to ocean warming. Nature Climate Change, 8: 1-6.

Banerjee, S., Ooi, M.C., Shariff, M. and Khatoon, H. A. (2012). Antibiotic resistant *Salmonella* and *Vibrio* associated with farmed *Litopenaeus vannamei.* Sci. World J*.,* 2021: 130136.

Baran, A., Kwiatkowska, A. and Potocki, L. (2023). Antibiotics and Bacterial Resistance—A Short Story of an Endless Arms Race. *International* Journal of Molecular Sciences, 24(6): 5777.

Barbosa, T. M., and Levy, S. B. (2000). The impact of antibiotic use on resistance development and persistence. Drug Resist. Updat., 3: 303–311.

Bauer, A.W. Kirby, W.M.M., Shenis, J.C. and Turck, M. (1966). Antibiotic susceptibility testing by a standardized single disk method. Am. J. Clin. Pathol., 45: 493.

Bej, A.K., Patterson, D.P., Brasher, C.W., Vickery, M.C.L., Jones, D.D. and Kaysner, C.A. (1999). Detection of total and hemolysin-producing *Vibrio parahaemolyticus* in shellfish using multiplex PCR amplification of *tlh*, *tdh* and *trh*. J. Microbiol. Methods, 36: 215–225.

Bell, R.L., Kase, J.A., Harrison, L.M., Balan, K.V., Babu, U., Chen, Y., Macarisin, D., Kwon, H.J., Zheng, J., Stevens, E.L. and Meng, J. (2021). The persistence of bacterial pathogens in surface water and its impact on global food safety. *Pathogens*. 10(11): 1391.

Bernáldez-Sarabia, J., Lizárraga-Partida, M. L., Hernández-López, E. L., Gasperin-Bulbarela, J., Licea-Navarro, A. F., Guerrero, A., Sánchez-Castrejón, E. and Franco-Moreno, A. (2021). Distribution of pathogenic vibrios and *Vibrio* spp. in the water column and sediment samples from the southern Gulf of Mexico. *Marine Pollution Bulletin.* 173: 113116.

Bharati, K. and Ganguly, N. K. (2011). Cholera toxin: a paradigm of a multifunctional protein. The Indian journal of medical research, 133(2): 179.

Blair, J. M., Webber, M. A., Baylay, A. J., Ogbolu, D. O. and Piddock, L. J. (2015). Molecular mechanisms of antibiotic resistance. Nature reviews microbiology, 13(1): 42-51.

Blair, J. M., Richmond, G. E. and Piddock, L. J. (2014). Multidrug efflux pumps in Gram-negative bacteria and their role in antibiotic resistance. Future Microbiol., 9: 1165–1177.

Broberg, C. A., Calder, T. J. and Orth, K. (2011). *Vibrio parahaemolyticus* cell biology and pathogenicity determinants. Microbes Infect., 13: 992–1001.

Brumfield, K. D., Usmani, M., Chen, K. M., Gangwar, M., Jutla, A. S., Huq, A., and Colwell, R. R. (2021). Environmental parameters associated with incidence and transmission of pathogenic *Vibrio* spp. Environmental microbiology. 23(12): 7314-7340.

Budiati, T., Rusul, G., Wan-Abdullah, W. N., Arip, Y. M., Ahmad, R. and Thong, K. L. (2013) Prevalence, antibiotic resistance and plasmid profiling of *Salmonella* in catfish (*Clarias gariepinus*) and tilapia (*Tilapia mossambica*) obtained from wet markets and ponds in Malaysia. Aquaculture, 372–375: 127–132.

Buller, N.B. (2015). Bacteria and Fungi from Fish and Other Aquatic Animals: *A Practice Identification Manual*, 2nd ed.; CABI Publishing: Wallingford, UK.

Bush, N. G., Diez-Santos, I., Abbott, L. R. and Maxwell, A. (2020). Quinolones: mechanism, lethality and their contributions to antibiotic resistance. Molecules, 25(23): 5662.

Cabanillas-Beltran, H., LLausas-Magaña, E., Romero, R., Espinoza, A., Garcia-Gasca, A., Nishibuchi, M., Ishibashi, M. and Gomez-Gil, B. (2006). Outbreak of gastroenteritis caused by the pandemic *Vibrio parahaemolyticus* O3: K6 in Mexico. FEMS Microbiol Lett., 265: 76-80.

Caburlotto, G., Suffredini, E., Toson, M., Fasolato, L., Antonetti, P., Zambon, M.; and Manfrin, A. (2016). Occurrence and molecular characterisation of *Vibrio parahaemolyticus* in crustaceans commercialised in Venice area, Italy. Int. J. Food Microbiol., 22: 39-49.

Caputo, A., Bondad-Reantaso, M.G., Karunasagar, I., Hao, B., Gaunt, P., Verner-Jeffreys, D., Fridman, S. and Dorado-Garcia, A. (2023). Antimicrobial resistance in aquaculture: A global analysis of literature and national action plans. Reviews in Aquaculture, 15(2): 568-578.

Chatterjee, S. and Haldar, S. (2012). *Vibrio* related diseases in aquaculture and development of rapid and accurate identification methods. J. Mar. Sci. Res. Dev., 1: 1-7.

Chen, W. & Gao, S. (2023). Current status of industrialized aquaculture in China: a review. Environmental Science and Pollution Research, 30(12): 32278-32287.

Chen, Q., Yan, Q., Wang, K., Zhuang, Z. Wang, X. (2008). Portal of entry for pathogenic *Vibrio alginolyticus* into large yellow croaker *Pseudosciaena crocea*, and characteristics of bacterial adhesion to mucus. Diseases of aquatic organisms, 80(3): 181-188.

Chenia, H. Y. and Jacobs, A. (2017). Antimicrobial resistance, heavy metal resistance and integron content in bacteria isolated from a South African tilapia aquaculture system. Diseases of aquatic organisms, 126(3): 199-209.

Chimetto, T.L., Brocchi, M., Gondo, M.L., Thompson, C.C., Gomez-Gil, B. and Thompson, F. (2009). Genomic diversity of Vibrios associated with the Brazilian coral Mussismilia hispida and its sympatric zoanthids (*Palythoa caribaeorum, Palythoa variabilis* and *Zoanthus solanderi*). J. Appl. Microbiol., 106: 1818–1826.

Chitov, T., Wongdao, S., Thatum, W., Puprae, T. and Sisuwan, P. (2009). Occurrence of potentially pathogenic *Vibrio* species in raw, processed, and ready-to-eat seafood and seafood products. Maejo Int. J. Sci. Technol., 3: 88–98.

Chonsin, K., Siriphap, A., Changkaew, K., Noisumdaeng, P. and Suthienkul, O. (2021). Virulence genes of *Vibrio parahaemolyticus* isolated from acute hepatopancreatic necrosis disease associated with shrimp and grow-out pond water. J Med Health Sci., 28**:** 17 – 27.

Chowdhury, M.A., Talib, A. and Yahya, K. (2012). A review on marine shrimp aquaculture production trend and sustainability in Malaysia and the world perspective. In Proceedings of the Conference: *International Fisheries Symposium*, Can Tho University, Can Tho, Vietnam (pp. 6-8).

Clinical Laboratory Standard Institute (CSLI). (2011). *Methods for Antimicrobial Dilution and Disk Susceptibility Testing of Infrequently Isolated or Fastidious Facteria; Approved Guideline*, 2nd ed.; CLSI document M45-A2: Wayne, PA, USA.

Coerdt, K. M. and Khachemoune, A. (2021). *Vibrio vulnificus*: review of mild to life-threatening skin infections. *Cutis.* 107(2): 12-17.

Conwell, M., Daniels, V., Naughton, P. J. and Dooley, J. S. G. (2017). Interspecies transfer of vancomycin, erythromycin and tetracycline resistance among Enterococcus species recovered from agrarian sources. BMC microbiology, 17: 1-8.

Croci, L., Suffredini, E., Cozzi, L., Toti, L., Ottaviani, D., Pruzzo, C., Serratore, P., Fischetti, R., Goffredo, E., Loffredo, G. and Mioni, R. (2007). Comparison of different biochemical and molecular methods for the identification of *Vibrio parahaemolyticus*. Journal of applied microbiology, 102(1): 229-237.

Darshanee Ruwandeepika, H. A., Sanjeewa Prasad Jayaweera, T., Paban Bhowmick, P., Karunasagar, I., Bossier, P. and Defoirdt, T. (2012). Pathogenesis, virulence factors and virulence regulation of vibrios belonging to the Harveyi clade. Reviews in Aquaculture, 4(2): 59-74.

De Nies, L., Lopes, S., Busi, S.B., Galata, V., Heintz-Buschart, A., Laczny, C.C., May, P. and Wilmes, P. (2021). PathoFact: a pipeline for the prediction of virulence factors and antimicrobial resistance genes in metagenomic data. *Microbiome* 9*:* 1-14.

de Souza Valente, C. and Wan, A. H. (2021). *Vibrio* and major commercially important vibriosis diseases in decapod crustaceans. *Journal of Invertebrate Pathology*. 181: 107527.

Defoirdt, T. (2014). Virulence mechanisms of bacterial aquaculture pathogens and antivirulence therapy for aquaculture. Reviews in Aquaculture, 6(2), 100-114.

Deng, Y., Xu, L., Chen, H., Liu, S., Guo, Z., Cheng, C., Ma, H. and Feng, J. (2020). Prevalence, virulence genes, and antimicrobial resistance of *Vibrio* species isolated from diseased marine fish in South China. Scientific Reports, 10(1): 1-8.

Department of Fisheries Malaysia (DOF). (2017). *Annual Fisheries Statistics*.

DOF (2020). Perangkaan Perikanan Tahunan 2020. Retrieved from https://www.dof.gov.my/index.php/pages/view/4046

DOF (2022). Perangkaan Perikanan Tahunan 2022.

Destoumieux-Garzón, D., Canesi, L., Oyanedel, D., Travers, M. A., Charrière, G. M., Pruzzo, C. and Vezzulli, L. (2020). *Vibrio*–bivalve interactions in health and disease. *Environmental Microbiology.* 22(10): 4323-4341.

Devi, R., Surendran, P. and Chakraborty, K. (2009). Antibiotic resistance and plasmid profiling of *Vibrio parahaemolyticus* isolated from shrimp farms along the Southwest coast of India. World J. Microbiol. Biotechnol., 25: 2005–2012.

Dhar, A.K., Piamsomboon, P., Aranguren Caro, L.F., Kanrar, S., Adami, R. Jr. and Juan YS. (2019). First report of acute hepatopancreatic necrosis disease (AHPND) occurring in the USA. Diseases of Aquatic Organisms, 132(3): 241-247.

Dhayanath, M., Kurcheti, P. P., Mary, S. J., Paul, T. and Majethia, H. (2019). Prevalence of antimicrobial resistance among *Vibrio* spp. isolated from the digestive tract of cultured *Penaeus vannamei.* Journal of Animal Research, 9(5): 675-681.

Dieguez, A.L., Beaz-Hidalgo, R., Cleenwerck, I., Balboa, S., de Vos, P. and Romalde, J.L. (2011) *Vibrio atlanticus* sp. nov. and *Vibrio artabrorum* sp. nov. isolated from the clams *Ruditapes philippinarum* and *Ruditapes decussatus*. Int. J. Syst. Evol. Microbiol., 61: 2406–2411.

Dionisio, F., Zilhão, R. and Gama, J. A. (2019). Interactions between plasmids and other mobile genetic elements affect their transmission and persistence. Plasmid, 102: 29-36.

Dong, X., Wang, H., Xie, G., Zou, P., Guo, C., Liang, Y. and Huang, J. (2017). An isolate of *Vibrio campbellii* carrying the pirVP gene causes acute hepatopancreatic necrosis disease. Emerg. Microbes Infect., 6: e2.

Dongre, M., Singh, B., Aung, K.M., Larsson, P., Miftakhova, R., Persson, K., Askarian, F., Johannessen, M., von Hofsten, J., Persson, J. L. and Erhardt, M. (2018.) Flagella-mediated secretion of a novel *Vibrio cholerae* cytotoxin affecting both vertebrate and invertebrate hosts. Communications Biology, 1(1): 59.

Dutta, S., Banerjee, K. K. and Ghosh, A. N. (2014). Cryo-electron microscopy reveals the membrane insertion mechanism of *V. cholerae* hemolysin. Journal of Biomolecular Structure and Dynamics, 32(9): 1434-1442.

Elias, H. M., Qader, M. K. and Salih, W. M. (2013). Determination of plasmid DNA role in multidrug resistant *Pseudomonas aeruginosa* clinical isolates. International Journal of Microbiology and Immunology Research, 1(8): 80- 86.

Elmahdi, S., DaSilva, L. V. and Parveen, S. (2016). Antibiotic resistance of *Vibrio parahaemolyticus* and *Vibrio vulnificus* in various countries: a review. Food microbiology, 57: 128-134.

El-Saadony, M.T., Swelum, A.A., Ghanima, M.M.A., Shukry, M., Omar, A.A., Taha, A.E., Salem, H.M., El-Tahan, A.M., El-Tarabily, K.A. and Abd El-Hack, M.E. (2022). Shrimp production, the most important diseases that threaten it, and the role of probiotics in confronting these diseases: A review. *Research in veterinary science*, 144: 126-140.

Epand, R. M., Walker, C., Epand, R. F. and Magarvey, N. A. (2016). Molecular mechanisms of membrane targeting antibiotics. Biochimica et Biophysica Acta (BBA)-Biomembranes, 1858(5): 980-987.

Evensen, Ø. (2016). Development of fish vaccines: Focusing on methods. Fish vaccines, 53-74.

FAO. (2018). The State of World Fisheries and Aquaculture – meeting the sustainable development goals. *Food and Agricultural Organization of the United Nations, Rome.*

FAO (2019). State of Fisheries and Aquaculture in the World. *Food and Agriculture Organization of the United Nations; Rome, Italy.*

FAO (2020) The state of world fisheries and aquaculture. Sustainability in action. *Food and Agricultural Organization of the United Nations, Rome*.

FAO (2021). World Food and Agriculture - Statistical Yearbook 2021. Rome.

FAO (2022). The State of World Fisheries and Aquaculture. Towards Blue Transformation. Rome.

FAO (2023). International markets for fisheries and aquaculture products – Fourth issue 2023, with January–June 2023 statistics. GLOBEFISH Highlights, No. 4–2023. Rome.

Faulds-Pain, A., Birchall, C., Aldridge, C., Smith, W.D., Grimaldi, G., Nakamura, S., Miyata, T., Gray, J., Li, G., Tang, J.X. and Namba, K. (2011). Flagellin redundancy in Caulobacter crescentus and its implications for flagellar filament assembly. Journal of bacteriology, 193(11): 2695-2707.

FDA, U. (2022). Approved aquaculture drugs. (Accessed on 6 October 2022).

Feng, B., Liu, H., Wang, M., Sun, X., Pan, Y. and Zhao, Y. (2017). Diversity analysis of acute hepatopancreatic necrosis disease-positive *Vibrio parahaemolyticus* strains. Aquaculture and fisheries, 2(6): 278-285.

Firmino, J., Furones, M. D., Andree, K. B., Sarasquete, C., Ortiz-Delgado, J. B., Asencio-Alcudia, G. and Gisbert, E. (2019). Contrasting outcomes of *Vibrio harveyi* pathogenicity in gilthead seabream, *Sparus aurata* and European seabass, *Dicentrachus labrax*. Aquaculture, 511: 734210.

Flegel, T. W. (2019). A future vision for disease control in shrimp aquaculture. *Journal of the World Aquaculture Society.* 50(2): 249-266.

Gangnonngiw, W. and Kanthong, N. (2023). Failed shrimp vaccination attempt with yellow head virus (YHV) attenuated in an immortal insect cell line. Fish and Shellfish Immunology Reports, 4: 100084.

Gao, Y., Chen, Z., Yao, W., Li, D. and Fu, X. (2021). Gentamicin combined with hypoionic shock rapidly eradicates aquaculture bacteria in vitro and in vivo. Frontiers in Microbiology, 12: 641846.

Garibyan, L. and Avashia, N. (2013). Research techniques made simple: Polymerase chain reaction (PCR). J. Investig. Dermatol., 133: e6.

Giuliodori, A.M., Spurio, R., Milon, P. and Fabbretti, A. (2019). Antibiotics Targeting the 30S Ribosomal Subunit: A Lesson from Nature to Find and Develop New Drugs. Curr. Top. Med. Chem*.,* 18: 2080–2096.

Guardiola-Avila, I., Martínez-Vázquez, V., Juárez-Rendón, K., Alvarez-Ainza, M., Paz-González, A. and Rivera, G. (2020). Prevalence and virulence of *Vibrio* species isolated from raw shrimp from retail markets in Reynosa, Mexico. Letters in Applied Microbiology, 71(3): 280-286.

Guardiola-Avila, I., Martínez-Vázquez, V., Requena-Castro, R., Juárez-Rendón, K., Aguilera-Arreola, M. G., Rivera, G. and Bocanegra-García, V. (2018). Isolation and identification of *Vibrio* species in the Rio Bravo/Grande and water bodies from Reynosa, Tamaulipas. Lett Appl Microbiol., 67(2): 190-196.

Guijarro, J. A., Cascales, D., García-Torrico, A. I., García-Domínguez, M. and Méndez, J. (2015). Temperature-dependent expression of virulence genes in fish-pathogenic bacteria. Frontiers in microbiology, 6: 700.

Gxalo, O., Digban, T. O., Igere, B. E., Olapade, O. A., Okoh, A. I. and Nwodo, U. U. (2021). Virulence and antibiotic resistance characteristics of *Vibrio* isolates from rustic environmental freshwaters. Frontiers in Cellular and Infection Microbiology, 765.

Haldar, S., Chatterjee, S., Sugimoto, N., Das, S., Chowdhury, N., Hinenoya, A., Asakura, M. and Yamasaki, S. (2011). Identification of *Vibrio campbellii* isolated from diseased farm-shrimps from south India and establishment of its pathogenic potential in an Artemia model. Microbiology, 157: 179–188.

Han, J.E., Tang, K.F.J., Tran, L.H. and Lightner, D.V. (2015). Photohabdus insect-related (Pir) toxin-like genes in a plasmid of *V. parahaemolyticus*, the causative agent of acute hepatopancreatic necrosis disease (AHPND) of shrimp. Disease of Aquatic Organisms, 113: 33- 40.

Harrison, J., Nelson, K., Morcrette, H., Morcrette, C., Preston, J., Helmer, L., Titball, R.W., Butler, C.S. and Wagley, S. (2022). The increased prevalence of *Vibrio* species and the first reporting of *Vibrio jasicida* and *Vibrio rotiferianus* at UK shellfish sites. Water Research, 211: 117942.

Hassali, M.A., Arief, M., Saleem, F., Khan, M.U., Ahmad, A., Mariam, W., Bheemavarapu, H. and Syed, I.A. (2017). Assessment of attitudes and practices of young Malaysian adults about antibiotics use: a cross-sectional study. Pharmacy Practice (Granada), 15(2): 929.

Hassan, Z. H.; Zwartkruis-Nahuis, J. T.; de Boer, E. (2012). Occurrence of *Vibrio parahaemolyticus* in retailed seafood in The Netherlands. International Food Research Journal, 19: 39-43.

Hazen, T.H., Lafon, P.C., Garrett, N.M., Lowe, T.M., Silberger, D.J. and Rowe, L.A. (2015). Insights into the environmental reservoir of pathogenic *Vibrio parahaemolyticus* using comparative genomics. Front. Microbiol., 6: 204.

He, X., Yu, M., Wu, Y., Ran, L., Liu, W. and Zhang, X. H. (2020). Two highly similar chitinases from marine *Vibrio* species have different enzymatic properties. Marine Drugs, 18(3): 139.

Henriksson, P.J., Rico, A., Troell, M., Klinger, D.H., Buschmann, A.H., Saksida, S., Chadag, M.V. and Zhang, W. (2018). Unpacking factors influencing antimicrobial use in global aquaculture and their implication for management: a review from a systems perspective. Sustainability Science, 13: 1105-1120.

Hernández-Cabanyero, C., Carrascosa, E., Jiménez, S. and Fouz, B. (2023). Exploring the Effect of Functional Diets Containing Phytobiotic Compounds in Whiteleg Shrimp Health: Resistance to Acute Hepatopancreatic Necrotic Disease Caused by *Vibrio parahaemolyticus*. Animals, 13(8): 1354.

Hikmawati, F., Susilowati, A., and Setyaningsih, R. (2019). Colony morphology and molecular identification of *Vibrio* spp. on green mussels (*Perna viridis*) in Yogyakarta, Indonesia tourism beach areas. Biodiversitas Journal of Biological Diversity, 20(10): 2891-2899.

Hinchliffe, S., Butcher, A. and Rahman, M. M. (2018). The AMR problem: demanding economies, biological margins, and co-producing alternative strategies. Palgrave Communications, 4(1): 1-12.

Hjerde, E., Lorentzen, M.S., Holden, M.T., Seeger, K., Paulsen, S., Bason, N., Churcher, C., Harris, D., Norbertczak, H., Quail, M.A. and Sanders, S. (2008). The genome sequence of the fish pathogen *Aliivibrio salmonicida* strain LFI1238 shows extensive evidence of gene decay. BMC genomics, 9(1): 1-14.

Hong To, T.T., Yanagawa, H., Khanh Thuan, N., Hiep, D.M., Cuong, D.V., Khai, L.T.L., Taniguchi, T., Kubo, R. and Hayashidani, H. (2020). Prevalence of *Vibrio parahaemolyticus* causing acute hepatopancreatic necrosis disease of shrimp in shrimp, molluscan shellfish and water samples in the Mekong Delta, Vietnam. Biology, 9(10): 312.

Horne, J. E., Brockwell, D. J. and Radford, S. E. (2020). Role of the lipid bilayer in outer membrane protein folding in Gram-negative bacteria. *Journal of Biological Chemistry.* 295(30): 10340-10367.

Hossain, M.M.M., Tanni, L.N., Rahman, M.A., Farjana, N., Moon, R.S., Tonni, N.Z., Mekat, M.R., Mojumdar, S., Rahman, N., Sen, B.K. and Rojoni, S.A. (2024). Bacteriophage and non-pathogenic *Vibrio* to control diseases in shrimp aquaculture. *Comparative Immunology Reports* 6: 200126.

Hossain, M. G. M., Islam, M. R., Mondol, G. C. and Alam, M. F. (2019). Antibiotic resistance analysis of *Vibrio* spp isolated from different types of water sources of Bangladesh and their characterization. *European Journal of Medical and Health Sciences.* 1(4): 19-29.

Hu, Y., Li, F., Zheng, Y., Jiao, X. and Guo, L. (2020). Isolation, molecular characterization and antibiotic susceptibility pattern of *Vibrio parahaemolyticus* from aquatic products in the southern Fujian Coast, China. Journal of Microbiology and Biotechnology, 30(6): 856.

Huang, L., Gao, Q., Zhang, Y., Xu, W., and Yan, Q. (2021). Community change and pathogenicity of *Vibrio*. IntechOpen., doi: 10.5772/intechopen.96515.

Huang, Z., Anokyewaa, M. A., Wang, J., Jian, J. and Lu, Y. (2022). Pathogenicity and antibiotic resistance analysis of *Vibrio* species found in coastal water at mainly beach of Shenzhen, China. Front. Mar. Sci., 9:980593.

Hunt, D.E., Gevers, D., Vahora, N.M. and Polz, M.F. (2008). Conservation of the chitin utilization pathway in the Vibrionaceae. Appl. Environ. Microbiol., 74: 44–51.

Ibrahim, M., Ahmad, F., Yaqub, B., Ramzan, A., Imran, A., Afzaal, M., Mirza, S.A., Mazhar, I., Younus, M., Akram, Q. and Taseer, M.S.A. (2020). Current trends of antimicrobials used in food animals and aquaculture. In Antibiotics and antimicrobial resistance genes in the environment (pp. 39-69). Elsevier.

Igbinosa, I. H., Igbinosa, E.O. and Okoh, A.I. (2015). Detection of antibiotic resistance, virulence gene determinants and biofilm formation in *Aeromonas* species isolated from cattle. Environ. Sci. Pollut. Res., 22:17596-17605.

Ina-Salwany, M.Y., Al-saari, N., Mohamad, A., Mursidi, F.A., Mohd-Aris, A., Amal, M.N.A., Kasai, H., Mino, S., Sawabe, T. and Zamri-Saad, M. (2019). Vibriosis in fish: a review on disease development and prevention. Journal of aquatic animal health, 31(1): 3-22.

Janda, J. M., Newton, A. E. and Bopp, C. A. (2015). Vibriosis. Clin. Lab. Med., 35: 273-288.

Jang, H. M., Kim, Y. B., Choi, S., Lee, Y., Shin, S. G., Unno, T. and Kim, Y. M. (2018). Prevalence of antibiotic resistance genes from effluent of coastal aquaculture, South Korea. Environmental pollution, 233: 1049-1057.

Jatuyosporn, T., Laohawutthichai, P., Supungul, P. (2021). *Pm*AP2-β depletion enhanced activation of the Toll signaling pathway during yellow head virus infection in the black tiger shrimp *Penaeus monodon*. Sci Rep., 11: 10534.

Jian, Z., Zeng, L., Xu, T., Sun, S., Yan, S., Yang, L., Huang, Y., Jia, J. and Dou, T. (2021). Antibiotic resistance genes in bacteria: Occurrence, spread, and control. Journal of basic microbiology, 61(12): 1049-1070.

Jiang, Q., Chen, J., Yang, C., Yin, Y. and Yao, K. (2019). Quorum sensing: a prospective therapeutic target for bacterial diseases. BioMed Research International, 2019.

Joshi, J., Srisala, J., Truong, V. H., Chen, I. T., Nuangsaeng, B., Suthienkul, O., Lo, C.F., Flegel, T.W., Sritunyalucksana, K. and Thitamadee, S. (2014). Variation in *V. parahaemolyticus* isolates from a single Thai shrimp farm experiencing an outbreak of acute hepatopancreatic necrosis disease (AHPND). Aquaculture, 428: 297-302.

Kabore, S., Cecchi, P., Mosser, T., Toubiana, M., Traore, O., Ouattara, A., Traore, A.S. and Barro, N. (2018). Occurrence of *Vibrio cholerae* in water reservoirs of Burkina Faso. Res Microbiol., 169: 1-10.

Kang, C.H., Shin, Y., Jang, S., Yu, H., Kim, S., An, S., Park, K. and So, J.S. (2017). Characterization of *Vibrio parahaemolyticus* isolated from oysters in Korea: Resistance to various antibiotics and prevalence of virulence genes. Marine Pollution Bulletin, 118(1-2): 261-266.

Kang, S. J., Jung, S. I. and Peck, K. R. (2020). Historical and clinical perspective of *Vibrio vulnificus* infections in Korea. Infection & Chemotherapy, 52(2): 245-251.

Kanoktippornchai, B., Chomvarin, C., Hahnvajanawong, C. and Nutrawong, T. (2014). Role of *hlyA*-positive *Vibrio cholerae* non-O1/non-O139 on apoptosis and cytotoxicity in a Chinese hamster ovary cell line. Southeast Asian J. Trop. Med. Public Health, 45: 1365-1375.

Kapoor, G., Saigal, S. and Elongavan, A. (2017). Action and resistance mechanisms of antibiotics: A guide for clinicians. Journal of anaesthesiology, clinical pharmacology, 33(3): 300.

Karunasagar, I., Pai, R., Malathi, G. R. and Karunasagar, I. (1994). Mass mortality of *Penaeus monodon* larvae due to antibiotic-resistant *Vibrio harveyi* infection. Aquaculture, 128(3-4): 203-209.

Kathleen, M. M., Samuel, L., Felecia, C., Reagan, E. L., Kasing, A., Lesley, M. and Toh, S. C. (2016). Antibiotic resistance of diverse bacteria from aquaculture in Borneo. *International journal of microbiology* 2016: 2164761.

Kim, K. I., Won, K. M., Lee, E. S., Cho, M., Jung, S. H. and Kim, M. S. (2019). Detection of *Vibrio* and ten *Vibrio* species in cage-cultured fish by multiplex polymerase chain reaction using house-keeping genes. Aquaculture, 506: 417- 423.

Kogut, M. H. and LaPatra, S. E. (2009). Gross lesion assessment as a tool for evaluating virulence in fish pathogens. Rev. in Aquaculture, 1(2): 71-79.

Kohli, V., Vaidhyanathan, R., Balange, A. K., Nayak, B. B. and Kumar, S. H. (2021). Distribution of *Vibrio parahaemolyticus* in Farmed Shrimp *Penaeus vannamei*, Farm Water and Sediment. *Journal of Pure & Applied Microbiology.* 15(3): 1608 - 1616.

Koralage, M.S., Alter, T., Pichpol, D., Strauch, E., Zessin, K.H. and Huehn, S. (2012). Prevalence and molecular characteristics of *Vibrio* spp. isolated from preharvest shrimp of the Northwestern Province of Sri Lanka. J. Food Prot., 75: 1846–1850.

Kriem, M.R., Banni, B., El Bouchtaoui, H., Hamama, A., El Marrakchi, A., Chaouqy, N., Robert-Pillot, A., Quilici, M.L. (2015). Prevalence of *Vibrio* spp. in raw shrimp (*Parapenaeus longirostris*) and performance of a chromogenic medium for the isolation of *Vibrio* strains. Lett. Appl. Microbiol., 61: 224–230.

Kumar, V., Roy, S., Behera, B. K., Bossier, P. and Das, B. K. (2021). Acute hepatopancreatic necrosis disease (AHPND): virulence, pathogenesis and mitigation strategies in shrimp aquaculture. Toxins*,* 13(8): 524.

Kumar, S. B., Arnipalli, S. R. and Ziouzenkova, O. (2020). Antibiotics in food chain: The consequences for antibiotic resistance. Antibiotics, 9(10): 688.

Kumar, V., Baruah, K., Nguyen, D.V., Smagghe, G., Vossen, E. and Bossier, P. (2018). Phloroglucinol mediated Hsp70 production in crustaceans: protection against *Vibrio parahaemolyticus* in *Artemia franciscana* and *Macrobrachium rosenbergii*. Front. Immunol., 9: 1091.

Kumar, S., Stecher, G. and Tamura, K. (2016). MEGA7: Molecular evolutionary genetics analysis version 7.0 for bigger datasets. *Mol. Biol. Evol.* 33: 1870–1874.

Kumari, T and Sinha, R. (2023). A review on plasmid curing in bacterial systems. Int. J. Res. Publ. Rev., 4(4): 4602-4609.

Laith, A.A., Ambak, M.A., Hassan, M., Sheriff, S.M., Nadirah, M., Draman, A.S., Wahab, W., Ibrahim, W.N.W., Aznan, A.S., Jabar, A. and Najiah, M. (2017). Molecular identification and histopathological study of natural *Streptococcus agalactiae* infection in hybrid tilapia (*Oreochromis niloticus*). *Veterinary world* 10(1): 101.

Le Hong, P., Corteel, M., Nguyen, C. T., Nauwynck, H., Pensaert, M., Alday-Sanz, V., Broeck, W. V. D., Sorgeloos, P. and Bossier, P. (2009). Effect of dose and challenge routes of *Vibrio* spp. on co-infection with white spot syndrome virus in *Penaeus vannamei*. Aquaculture, 290(1–2): 61–68.

Lee, C. T., Chen, I. T., Yang, Y. T., Ko, T. P., Huang, Y. T., Huang, J. Y., Huang, M.F., Lin, S.J., Chen, C.Y., Lin, S.S. and Lightner, D.V (2015). The opportunistic marine pathogen *Vibrio parahaemolyticus* becomes virulent by acquiring a plasmid that expresses a deadly toxin. Proc. Natl. Acad. Sci. U.S.A., 112: 10798–10803.

Lee, L. H., Ab Mutalib, N. S., Law, J. W. F., Wong, S. H. and Letchumanan, V. (2018). Discovery on antibiotic resistance patterns of *Vibrio parahaemolyticus* in Selangor reveals carbapenemase producing *Vibrio parahaemolyticus* in marine and freshwater fish. Frontiers in microbiology, 9: 2513.

Lee, P. T., Huang, J., Huang, C. Y., Liu, Z. X., Yeh, H. Y, Huang, H. T, Chen, L. L, Nan, F. H and Lee, M.C. (2021). Phycoerythrin from *Colaconema* sp. has immunostimulatory effects on the whiteleg shrimp *Litopenaeus vannamei* and increases resistance to *Vibrio parahaemolyticus* and white spot syndrome virus. Animals, 11(8): 2371.

Lee, S.E., Kim, S.Y., Kim, C.M., Kim, M.K., Kim, Y.R., Jeong, K., Ryu, H.J., Lee, Y.S., Chung, S.S., Choy, H.E. and Rhee, J.H. (2007). The *pyrH* gene of *Vibrio vulnificus* is an essential in vivo survival factor. Infection and immunity, *75*(6): 2795-2801.

Leitão, J. H. (2020). Microbial virulence factors. International Journal of Molecular Sciences, 21(15): 5320.

Lesley, M.B., Velnetti, L., Cheah, Y.K., Son, R., Kasing, A., Samuel, L., Micky, V. and Nishibuchi, M. (2011). Antibiotic resistance and plasmid profiling of *Vibrio parahaemolyticus* isolated from cockles (*Anadara granosa*) at Tanjung Karang, Kuala Selangor. International Food Research Journal, 18(3): 1183-1188.

Letchumanan, V., Chan, K. G. and Lee, L. H. (2014). *Vibrio parahaemolyticus*: a review on the pathogenesis, prevalence, and advance molecular identification techniques. Frontiers in microbiology, 5: 705.

Letchumanan, V., Chan, K-G, and Lee, L-H. (2015) An insight of traditional plasmid curing in *Vibrio* species. Front. Microbiol., 6:735.

Letchumanan, V., Ab Mutalib, N. S., Wong, S. H., Chan, K. G. and Lee, L. H. (2019). Determination of antibiotic resistance patterns of *Vibrio parahaemolyticus* from shrimp and shellfish in Selangor, Malaysia. Progress in Microbes & Molecular Biology, *2*(1).

Li, Y., Xie, T., Pang, R., Wu, Q., Zhang, J., Lei, T., Xue, L., Wu, H., Wang, J., Ding, Y. and Chen, M. (2020). Food-borne *Vibrio parahaemolyticus* in China: prevalence, antibiotic susceptibility, and genetic characterization. Frontiers in microbiology, 11: 1670.

Li, L., Meng, H., Gu, D., Li, Y. and Jia, M. (2019). Molecular mechanisms of *Vibrio parahaemolyticus* pathogenesis. Microbiological Research, 222: 43-51.

Li, X., Zhou, Y., Jiang, Q., Yang, H., Pi, D., Liu, X., Gao, X., Chen, N. and Zhang, X. (2019). Virulence properties of *Vibrio vulnificus* isolated from diseased zoea of freshness shrimp *Macrobrachium rosenbergii*. Microbial pathogenesis, 127: 166-171.

Li, W. and Zhang, G. (2022). Detection and various environmental factors of antibiotic resistance gene horizontal transfer. Environmental Research, 212: 113267.

Liang, H., Xia, L., Wu, Z., Jian, J. and Lu, Y. (2010). Expression, characterization and immunogenicity of flagellin *FlaC* from *Vibrio alginolyticus* strain HY9901. Fish & shellfish immunology, 29(2): 343-348.

Liang, J.F., Peng, C., Li, P., Ye, Q.X., Wang, Y., Yi, Y.T., Yao, Z.S., Chen, G.Y., Zhang, B.B., Lin, J.J. and Luo, Q. (2021). A review of detection of antibiotic residues in food by surface-enhanced Raman spectroscopy. Bioinorganic Chemistry and Applications, 2021.

Liu, G., Thomsen, L. E., & Olsen, J. E. (2022). Antimicrobial-induced horizontal transfer of antimicrobial resistance genes in bacteria: A mini-review. Journal of Antimicrobial Chemotherapy, 77(3): 556-567.

Liu, X., Wang, D., Wang, H., Feng, E. and Zhu L. (2012). Curing of plasmid pXO1 from *Bacillus anthracis* using plasmid incompatibility. PLoS ONE, 7: e29875.

Loo, K. Y., Law, J. W. F., Tan, L. T. H., Pusparajah, P., Letchumanan, V. and Lee, L. H. (2022). Diagnostic techniques for rapid detection of *Vibrio* species. Aquaculture, 738628.

Lulijwa, R., Rupia, E. J. and Alfaro, A. C. (2020). Antibiotic use in aquaculture, policies and regulation, health and environmental risks: a review of the top 15 major producers. Reviews in Aquaculture, 12(2): 640-663.

Luu, Q. H., Nguyen, T. B. T., Nguyen, T. L. A., Do, T. T. T., Dao, T. H. T. and Padungtod, P. (2021). Antibiotics use in fish and shrimp farms in Vietnam. Aquaculture Reports, 20: 100711.

Lynch, S. V. and Wiener-Kronish, J. P. (2008). Novel strategies to combat bacterial virulence. Curr Opin Crit Care, 14(5):593-599.

Madhuri, A., Rao, D., Verma, M., Jithendra, M. and Raghavendra, R. (2021). Treatment of gregarines sporozoites in shrimp with allicin an herbal preparation and control intermediate hosts with copper sulphate. Int. J. Fish Aquat. Stud., 9(4): 37-40.

Manjusha, S. and Sarita, G.B. (2012). Characterization of plasmids from multiple antibiotic resistant *Vibrio* sp. isolated from mollucsc and crustaceans. Kor.J. Microbiol.Biotechnol., 40: 197–207.

Martinez, V. A., Schwarz-Linek, J., Reufer, M., Wilson, L. G., Morozov, A. N. and Poon, W. C. (2014). Flagellated bacterial motility in polymer solutions. Proceedings of the National Academy of Sciences, 111(50): 17771-17776.

Mata, W., Putita, C., Dong, H. T., Kayansamruaj, P., Senapin, S., & Rodkhum, C. (2018). Quinolone-resistant phenotype of *Flavobacterium columnare* isolates harbouring point mutations both in *gyrA* and *parC* but not in *gyrB* or *parE*. Journal of Global Antimicrobial Resistance,15: 55-60.

McEwen, S. A. and Collignon, P. J. (2018). Antimicrobial resistance: a one health perspective. Microbiol Spectr., 6(2): 521-547.

Meibom, K.L., Li, X.B., Nielsen, A.T., Wu, C.-Y., Roseman, S. and Schoolnik, G.K. (2004). The *Vibrio cholerae* chitin utilization program. Proc. Natl. Acad. Sci. USA, 101: 2524–2529.

Melander, R. J., Zurawski, D. V. and Melander, C. (2018). Narrow-spectrum antibacterial agents. Medchemcomm, 9(1): 12-21.

Melo, L. M. R. D., Almeida, D., Hofer, E., Reis, C. M. F. D., Theophilo, G. N. D., Santos, A. F. D. M. and Vieira, R. H. S. D. F. (2011). Antibiotic resistance of *Vibrio parahaemolyticus* isolated from pond-reared *Litopenaeus vannamei* marketed in Natal, Brazil. Brazilian Journal of Microbiology, 42: 1463-1469.

Menezes, F. G. D., Rodriguez, M. T., Carvalho, F. C. D., Rebouças, R. H., Costa, R. A., Sousa, O. V., Hofer, E. and Vieira, R. H. (2017). Pathogenic *Vibrio* species isolated from estuarine environments (Ceará, Brazil)-antimicrobial resistance and virulence potential profiles. Anais da Academia Brasileira de Ciências, 89: 1175-1188.

Meparambu Prabhakaran, D., Ramamurthy, T. and Thomas, S. (2020). Genetic and virulence characterisation of *Vibrio parahaemolyticus* isolated from Indian coast. BMC microbiology, 20: 1-14.

Mhuantong, W., Charoensawan, V., Kanokratana, P., & Tangphatsornruang, S. (2021). Chitinases and chitin utilization in pathogenic and environmental microorganisms. Journal of microbiology and biotechnology, 31(9): 1143-1158.

Mohamad, N., Amal, M.N.A., Yasin, I.S.M., Saad, M.Z., Shaqinah, N.N., Al-saari, N., Mino, S. and Sawabe, T. (2019). Vibriosis in cultured marine fishes: a review. Aquaculture, 512: 734289.

Mohania, D., Nagpal, R., Kumar, M., Bhardwaj, A., Yadav, M., Jain, S., Marotta, F., Singh, V., Parkash, O. and Yadav, H. (2008). Molecular approachhes for identification and chacterization of Lactic acid bacteria. Journal of Digestive Discussion, 9:190-198.

Mok, J. S., Ryu, A., Kwon, J. Y., Kim, B. and Park, K. (2019). Distribution of *Vibrio* species isolated from bivalves and bivalve culture environments along the Gyeongnam coast in Korea: Virulence and antimicrobial resistance of Vibrio parahaemolyticus isolates. Food Control, 106: 106697.

Mokracka, J., Koczura, R., and Kaznowski, A. (2012). Multiresistant enterobacteriaceae with class 1 and class 2 integrons in a municipal wastewater treatment plant. Water Res., 46:3353.

Morales-Covarrubias, M. S., Cuéllar-Anjel, J., Varela-Mejías, A. and Elizondo-Ovares, C. (2018). Shrimp bacterial infections in Latin America: a review. Asian Fisheries Science, 31: 76-87.

Mougin, J., Flahaut, C., Roquigny, R., Bonnin-Jusserand, M., Grard, T. and Le Bris, C. (2020). Rapid identification of *Vibrio* Species of the *harveyi* clade using MALDI-TOF MS profiling with main spectral profile database implemented with an in-house database: luvibase. Frontiers in microbiology, 11: 586536.

Mulyadi, I. N. and Iba, W. (2020). Efficacy of seaweed (*Sargassum* sp.) extract to prevent vibriosis in white shrimp (*Litopenaeus vannamei*) juvenile. International Journal of Zoological Research, 16: 1-11.

Mustapha, S., Mustapha, E. M. and Nozha, C. (2013). *Vibrio alginolyticus*: an emerging pathogen of foodborne diseases. International Journal of Science and Technology, 2(4): 302-309.

Muthukrishnan, S., Defoirdt, T., Ina-Salwany, M.Y., Yusoff, F.M., Shariff, M., Ismail, S.I. and Natrah, I. (2019). *Vibrio parahaemolyticus* and *Vibrio harveyi* causing Acute Hepatopancreatic Necrosis Disease (AHPND) in *Penaeus vannamei* (Boone, 1931) isolated from Malaysian shrimp ponds. Aquaculture, 511: 734227.

Muthulakshmi, T. and Mothadaka, M. P. (2023). *Vibrio vulnificus* and Its Antimicrobial Resistance. In *Handbook on Antimicrobial Resistance: Current Status, Trends in Detection and Mitigation Measures* (pp. 1-18). Singapore: Springer Nature Singapore.

Natrah, F. M. I., Defoirdt, T., Sorgeloos, P. and Bossier, P. (2011). Disruption of bacterial cell-to-cell communication by marine organisms and its relevance to aquaculture. Marine Biotechnology, 13: 109-126.

Naylor, R., Fang, S. and Fanzo, J. (2023). A global view of aquaculture policy. Food Policy, 116: 102422.

Ngangom, B. L., Tamunjoh, S. S. A. and Boyom, F. F. (2019). Antibiotic residues in food animals: Public health concern. Acta Ecologica Sinica, 39(5): 411-415.

Nguyen, F., Starosta, A. L., Arenz, S., Sohmen, D., Dönhöfer, A. and Wilson, D. N. (2014). Tetracycline antibiotics and resistance mechanisms. Biological chemistry, 395(5): 559-575.

Noorlis, A., Ghazali, F.M., Cheah, Y.K., Tuan Zainazor, T.C., Wong, W.C., Tunung, R, Nishibuchi, M., Nakaguchi, Y. and Son, R.; Pui, C.F. (2011). Antibiotic resistance and biosafety of *Vibrio cholera* and *Vibrio parahaemolyticus* from freshwater fish at retail level. Int. Food Res. J., 18: 59–66.

Novais, C., Campos, J., Freitas, A.R., Barros, M., Silveira, E., Coque, T.M., Antunes, P. and Peixe, L. (2018). Water supply and feed as sources of antimicrobial-resistant Enterococcus spp. in aquacultures of rainbow trout (*Oncorhyncus mykiss*), Portugal. Science of the Total Environment, 625: 1102-1112.

Nsofor, C. A., Nwokenkwo, V. N. and Ohale, C. U. (2016). Prevalence and antibiotic susceptibility pattern of *Staphylococcus aureus* isolated from various clinical specimens in south-East Nigeria. MOJ Cell Sci Rep., 3(2): 1-5.

Nurhafizah, W. W. I., Leong, L., Abdul Razzak, L., Nadirah, M., Danish-Daniel, M., Zainathan, S. and Najiah, M. (2021). Virulence properties and pathogenicity of multidrug-resistant *Vibrio harveyi* associated with luminescent vibriosis in Pacific white shrimp, *Penaeus vannamei*. Journal of Invertebrate Pathology, 186(14): 107594.

O'Hara, C.M., Sowers, E.G., Bopp, C.A., Duda, S.B. and Strockbine, N.A. (2003). Accuracy of six commercially available systems for identification of members of the family Vibrionaceae. J. Clin. Microbiol., 41: 5654–5659.

OIE (Office International des Epizooties), (2020). Information on aquatic and terrestrial animal diseases. Retrieved from https://www.oie.int/en/animal-health-in-the-world /information-on-aquatic-and-terrestrial-animal-diseases/ Date of access: 31 March 2024

Okeke, E.S., Chukwudozie, K.I., Nyaruaba, R., Ita, R.E., Oladipo, A., Ejeromedoghene, O., Atakpa, E.O., Agu, C.V. and Okoye, C.O. (2022). Antibiotic resistance in aquaculture and aquatic organisms: a review of current nanotechnology applications for sustainable management. Environmental Science and Pollution Research, 29(46): 69241-69274.

Ottaviani, D., Masini, L. and Bacchiocchi, S. (2003). A biochemical protocol for the isolation and identification of current species of *Vibrio* in seafood. Journal of Applied Microbiology, 95(6): 1277-1284.

Ottaviani, D., Leoni, F., Talevi, G., Masini, L., Santarelli, S., Rocchegiani, E., Susini, F., Montagna, C., Monno, R., D'Annibale, L. and Manso, E. (2013). Extensive investigation of antimicrobial resistance in *Vibrio parahaemolyticus* from shellfish and clinical sources, Italy. International journal of antimicrobial agents, 42(2): 191-193.

Ozaktas, T., Taskin, B. and Gozen, A. G. (2012). High level multiple antibiotic resistance among fish surface associated bacterial populations in non-aquaculture freshwater environment. Water research, 46(19): 6382-6390.

Pandey, N. and Cascella M. (2022). Beta Lactam Antibiotics. In: *StatPearls*. StatPearls Publishing, Treasure Island (FL). PMID: 31424895.

Paopradit, P., Tansila, N., Surachat, K. and Mittraparp-Arthorn, P. (2021). *Vibrio alginolyticus* influences quorum sensing-controlled phenotypes of acute hepatopancreatic necrosis disease-causing *Vibrio parahaemolyticus*. PeerJ., 9: e11567.

Paria, P., Behera, B. K., Mohapatra, P. K. D. and Parida, P. K. (2021). Virulence factor genes and comparative pathogenicity study of *tdh*, *trh* and *tlh* positive *Vibrio parahaemolyticus* strains isolated from Whiteleg shrimp, *Litopenaeus vannamei* (Boone, 1931) in India. Infection, Genetics and Evolution, 95: 105083.

Park, K., Mok, J. S., Kwon, J. Y., Ryu, A. R., Kim, S. H. and Lee, H. J. (2018). Food-borne outbreaks, distributions, virulence, and antibiotic resistance profiles of *Vibrio parahaemolyticus* in Korea from 2003 to 2016: a review. Fisheries and Aquatic Sciences, 21*:* 1-10.

Pascual, J., Macián, M.C., Arahal, D.R., Garay, E. and Pujalte, M.J. (2010). Multilocus sequence analysis of the central clade of the genus *Vibrio* by using the 16S rRNA, *recA*, *pyrH*, *rpoD*, *gyrB*, *rctB* and *toxR* genes. Int. J. Syst. Evol. Microbiol., 60: 154–165.

Pazhani, G. P., Chowdhury, G. and Ramamurthy, T. (2021). Adaptations of *Vibrio parahaemolyticus* to stress during environmental survival, host colonization, and infection. Frontiers in Microbiology, 12: 737299.

Peraro, M. D. and Van Der Goot, F. G. (2016). Pore-forming toxins: ancient, but never really out of fashion. Nature reviews microbiology, 14(2): 77-92.

Phu, T. M., Phuong, N. T., Scippo, M. L. and Dalsgaard, A. (2015). Quality of antimicrobial products used in striped catfish (*Pangasianodon hypophthalmus*) aquaculture in Vietnam. PloS one, 10(4): e0124267.

Piamsomboon, P. and Han, J. E. (2022). White feces syndrome, a multifactorial syndrome of cultured shrimp: a mini review. Fishes. 7(6): 339.

Piddock, L. Multidrug-resistance efflux pumps? not just for resistance. (2016). Nat Rev Microbiol., 4: 629–636.

Preena, P. G., Swaminathan, T. R., Kumar, V. J. R. and Singh, I. S. B. (2020). Antimicrobial resistance in aquaculture: a crisis for concern. Biologia, 75: 1497-1517.

Raghunath P. (2015). Roles of thermostable direct hemolysin (*TDH*) and TDH-related hemolysin (*TRH*) in *Vibrio parahaemolyticus*. Front Microbiol., 5:805.

Rajendhran, J. and Gunasekaran, P. (2011). Microbial phylogeny and diversity: Small subunit ribosomal RNA sequence analysis and beyond. Microbiol. Res., 166: 99–110.

Ramamurthy, T., Nandy, R.K., Mukhopadhyay, A.K., Dutta, S., Mutreja, A., Okamoto, K., Miyoshi, S.I., Nair, G. B. and Ghosh, A. (2020). Virulence regulation and innate host response in the pathogenicity of *Vibrio cholerae*. Frontiers in Cellular and Infection Microbiology, 10: 572096.

Ramirez, M. S. and Tolmasky, M. E. (2010). Aminoglycoside modifying enzymes. Drug Resist Update, 13: 151–171.

Rasti, E. S. and Brown, A. C. (2019). Cholera toxin encapsulated within several *Vibrio cholerae* O1 serotype Inaba outer membrane vesicles lacks a functional B-subunit. Toxins, 11(4): 207.

Rebouças, R. H., de Sousa, O. V., Lima, A. S., Vasconcelos, F. R., de Carvalho, P. B. and dos Fernandes Vieira, R. H. S. (2011). Antimicrobial resistance profile of *Vibrio* species isolated from marine shrimp farming environments (*Litopenaeus vannamei*) at Ceará, Brazil. Environmental research, 111(1): 21-24.

Redgrave, L. S., Sutton, S. B., Webber, M. A. and Piddock, L. J. (2014). Fluoroquinolone resistance: mechanisms, impact on bacteria, and role in evolutionary success. Trends in microbiology, 22(8): 438-445.

Rengga, W. D. P., Putri, E. C. J., Wulansarie, R., & Suryanto, A. (2018). Ozone disinfection of *Vibrio vulnificus* in shrimp pond water. In IOP Conference Series: Materials Science and Engineering (Vol. 316, No. 1, p. 012067). IOP Publishing.

Rowley, A. F. and Pope, E. C. (2012). Vaccines and crustacean aquaculture-a mechanistic exploration. Aquaculture, 334: 1-11.

Rozman, U., Duh, D., Cimerman, M. and Turk, S.Š. (2020). Hospital Wastewater Effluent: Hot Spot for Antibiotic Resistant Bacteria. J. Water Sanit. Hyg. Dev., 10: 171–178.

Rutherford, S. T. and Bassler, B. L. (2012). Bacterial quorum sensing: its role in virulence and possibilities for its control. Cold Spring Harbor perspectives in medicine 2(11): a012427.

Ruwandeepika, H. A. D., Defoirdt, T., Bhowmick, P. P., Shekar, M., Bossier, P. and Karunasagar, I. (2010). Presence of typical and atypical virulence genes in *Vibrio* isolates belonging to the Harveyi clade. Journal of Applied Microbiology, 109(3): 888-899.

Saavedra, J., Grandón, M., Villalobos-González, J., Bohle, H., Bustos, P. and Mancilla, M. (2018). Isolation, functional characterization and transmissibility of p3PS10, a multidrug resistance plasmid of the fish pathogen *Piscirickettsia salmonis*. Frontiers in microbiology, 9: 923.

Sampaio, A., Silva, V., Poeta, P. and Aonofriesei, F. (2022). *Vibrio* spp.: Life Strategies, Ecology, and Risks in a Changing Environment. Diversity, 14(2): 97.

Sanches-Fernandes, G. M., Sá-Correia, I. and Costa, R. (2022). Vibriosis outbreaks in aquaculture: addressing environmental and public health concerns and preventive therapies using gilthead seabream farming as a model system. Frontiers in microbiology, 13: 904815.

Santos, H. M., Tsai, C. Y., Maquiling, K. R. A., Tayo, L. L., Mariatulqabtiah, A. R., Lee, C. W. and Chuang, K. P. (2020). Diagnosis and potential treatments for acute hepatopancreatic necrosis disease (AHPND): a review. Aquaculture International, 28: 169-185.

Santos, L., & Ramos, F. (2018). Antimicrobial resistance in aquaculture: Current knowledge and alternatives to tackle the problem. International Journal of Antimicrobial Agents, 52(2): 135-143.

Saraswati, E. and Wijaya, A. S. (2019). Antibacterial activities of *Physalis angulata* herb extract on white feces diseases (WFD) in Litopenaeus shrimp vannamei. In *IOP Conference Series: Earth and Environmental Science* (Vol. 236, No. 1, p. 012103). IOP Publishing.

Saravanan V., Kumar H. S., Karunasagar I. and Karunasagar, I. (2007). Putative virulence genes of *Vibrio cholerae* from seafoods and the coastal environment of Southwest India. Int J Food Microbiol., 119: 329-333.

Sarjito, S. and Sabdono, A. (2021). Associated *Vibrio* species in shrimp vibriosis from traditional brackish water pond in the North Coastal of central Java, Indonesia. Genetics of Aquatic Organism, 5(2): 45-54.

Sarkar, P., Issac, P. K., Raju, S. V., Elumalai, P., Arshad, A. and Arockiaraj, J. (2021). Pathogenic bacterial toxins and virulence influences in cultivable fish. Aquaculture Research, 52(6): 2361-2376.

Sawabe, T., Ogura, Y., Matsumura, Y., Feng, G., Amin, A.R., Mino, S., Nakagawa, S., Sawabe, T., Kumar, R., Fukui, Y. and Satomi, M. (2013). Updating the *Vibrio* clades defined by multilocus sequence phylogeny: proposal of eight new clades, and the description of *Vibrio tritonius* sp. nov. Frontiers in microbiology, 4: 414.

Schar, D., Klein, E. Y., Laxminarayan, R., Gilbert, M. and Van Boeckel, T. P. (2020). Global trends in antimicrobial use in aquaculture. Scientific reports, 10(1): 21878.

Schroeder, M., Brooks, B. D. and Brooks, A. E. (2017). The complex relationship between virulence and antibiotic resistance. Genes, 8: 39.

Schmitt, B. L., Leal, B. F., Leyser, M., de Barros, M. P., Trentin, D. S., Ferreira, C. A. S. and de Oliveira, S. D. (2023). Increased ompW and ompA expression and higher virulence of *Acinetobacter baumannii* persister cells. BMC microbiology, 23(1): 157.

Sechi, L.A., Duprè, I. and Deriu, A. (2000). Distribution of *V. cholerae* virulence genes among different *Vibrio* species isolated in Sardinia, Italy. J. Appl. Microbiol., 88:475–481.

Shah, S. Q., Cabello, F. C., L'Abée-Lund, T. M., Tomova, A., Godfrey, H. P., Buschmann, A. H. and Sørum, H. (2014). Antimicrobial resistance and antimicrobial resistance genes in marine bacteria from salmon aquaculture and non-aquaculture sites. Environmental microbiology, 16(5): 1310-1320.

Sharma, C., Rokana, N., Chandra, M., Singh, B.P., Gulhane, R.D., Gill, J.P.S., Ray, P., Puniya, A.K. and Panwar, H. (2018). Antimicrobial resistance: its surveillance, impact, and alternative management strategies in dairy animals. Frontiers in veterinary science, 4: 237.

Sheikh, H. I., Najiah, M., Fadhlina, A., Laith, A. A., Nor, M. M., Jalal, K. C. A., and Kasan, N. A. 2022. Temperature upshift mostly but not always enhances the growth of *Vibrio* species: a systematic review. Frontiers in Marine Science, 9: 959830.

Shinn, A. P., Pratoomyot, J., Griffiths, D., Trong, T. Q., Vu, N. T., Jiravanichpaisal, P. and Briggs, M. (2018). Asian shrimp production and the economic costs of disease. Asian Fish. Sci. S, 31: 29-58.

Sionov, R. V. and Steinberg, D. (2022). Targeting the holy triangle of quorum sensing, biofilm formation, and antibiotic resistance in pathogenic bacteria. Microorganisms, 10(6): 1239.

Sirikharin, R., Taengchaiyaphum, S., Sanguanrut, P., Chi, T.D., Mavichak, R., Proespraiwong, P., Nuangsaeng, B., Thitamadee, S., Flegel, T.W. and Sritunyalucksana, K. (2015). Characterization and PCR detection of binary, *Pir*-like toxins from *Vibrio parahaemolyticus* isolates that cause acute hepatopancreatic necrosis disease (AHPND) in shrimp. PloS one, 10(5): e0126987.

Soto-Rodriguez, S. A., Gomez-Gil, B., Lozano-Olvera, R., Betancourt-Lozano, M. and Morales-Covarrubias, M. S. (2015). Field and experimental evidence of *Vibrio parahaemolyticus* as the causative agent of acute hepatopancreatic necrosis disease of cultured shrimp (*Litopenaeus vannamei*) in Northwestern Mexico. Applied and Environmental Microbiology, 81(5): 1689-1699.

Soto-Rodriguez, S. A., Gomez-Gil, B., Lozano-Olvera, R., Bolanmejia, C., Aguilar-Rendon, K.G. and Enciso-Ibarra, J. (2018). Pathological, genomic and phenotypical characterization of *Vibrio parahaemolyticus*, causative agent of acute hepatopancreatic necrosis disease (AHPND) in Mexico. Asian Fish. Sci*.*, 31: 102Y111.

Sperling, L., Alter, T. and Huehn, S. (2015). Prevalence and antimicrobial resistance of *Vibrio* spp. in retail and farm shrimp in Ecuador. J. Food Prot*.,* 78: 2089–2092.

Stork, M., Di Lorenzo, M., Welch, T.J., Crosa, L.M. and Crosa, J.H. (2002) Plasmid-mediated iron uptake and virulence in *Vibrio anguillarum*. Plasmid, 48: 222–228.

Sudha, S., Divya, P. S., Francis, B. and Hatha, A. A. (2014). Prevalence and distribution of *Vibrio parahaemolyticus* in finfish from Cochin (South India*).* Vet Ital., 48(269): e81.

Sulis, G., Pradhan and R. and Kotwani, A. (2022). India's ban on antimicrobial fixed-dose combinations: winning the battle, losing the war?. J of Pharm Policy and Pract., 15: 33.

Sullivan, T.J. and Neigel, J.E. (2018). Effects of temperature and salinity on prevalence and intensity of infection of blue crabs, *Callinectes sapidus*, by *Vibrio cholerae, V. parahaemolyticus,* and *V. vulnificus* in Louisiana. J. Invertebr. Pathol., 151:82–90.

Sun, J., Deng, Z. and Yan, A. (2014). Bacterial multidrug efflux pumps: mechanisms, physiology and pharmacological exploitations. Biochemical and Biophysical Research Communications, 453(2): 254-267.

Suresh, K., Srinu, R., Pillai, D. and Rajesh, G. (2018). Hepatopancreatic microsporidiasis (HPM) in shrimp culture: a review. *International* Journal of Current Microbiology and Applied Sciences*, 7*(01): 3208-3215.

Takahashi, A., Kenjyo, N., Imura, K., Myonsun, Y. and Honda, T. (2000). Cl (-) secretion in colonic epithelial cells induced by the *Vibrio parahaemolyticus* hemolytic toxin related to thermostable direct hemolysin. Infect Immun. 68(9):5435-5438.

Tall, A., Hervio-Heath, D., Teillon, A., Boisset-Helbert, C., Delesmont, R., Bodilis, J. and Touron-Bodilis, A. (2013.) Diversity of *Vibrio* spp. isolated at ambient environmental temperature in the Eastern English Channel as determined by *pyrH* sequencing. Journal of Applied Microbiology, 114: 1713-1724.

Tan, C.W., Rukayadi, Y., Hasan, H., Thung, T.Y., Lee, E., Rollon, W.D., Hara, H., Kayali, A.Y., Nishibuchi, M. and Radu, S. (2020). Prevalence and antibiotic resistance patterns of *Vibrio parahaemolyticus* isolated from different types of seafood in Selangor, Malaysia. Saudi Journal of Biological Sciences, 27(6): 1602-1608.

Tan, C.W., Malcolm, T.T., Kuan, C.H., Thung, T.Y., Chang, W.S., Loo, Y.Y., Premarathne, J.M., Ramzi, O.B., Norshafawatie, M.F., Yusralimuna, N. and Rukayadi, Y. (2017). Prevalence and antimicrobial susceptibility of *Vibrio parahaemolyticus* isolated from short mackerels (*Rastrelliger brachysoma*) in Malaysia. Frontiers in microbiology, 8: 1087.

Tan, S. Y., Sethupathi, S., Leong, K. H., & Ahmad, T. (2024). Challenges and opportunities in sustaining aquaculture industry in Malaysia. Aquaculture International, 32(1): 489-519.

Tang, K. W. K., Millar, B. C., & Moore, J. E. (2023). Antimicrobial resistance (AMR). British Journal of Biomedical Science, 80: 11387.

Thakur, A., Vaidya, R. B. and Suryawanshi, S. A. (2003). Pathogenicity and antibiotic susceptibility of *Vibrio* species isolated from moribund shrimps. Indian Journal of Marine Sciences,32: 71-75.

Thomas, B. T., Agu, G. C., Makanjuola, S. O. and Davies, A. (2015). Plasmid profiling and antibiotic resistance of extended spectrum beta lactamases producing *Pseudomonas aeruginosa* expressing Ampc beta-lactamase enzyme. Am. Eurasian J. Sci. Res., 10: 109-117.

Thompson, F.L., Gomez-Gil, B., Ribeiro-Vasconcelos, A.T. and Sawabe, T. (2007). Multilocus sequence analysis reveals that *Vibrio harveyi* and *Vibrio campbellii* form distinct species. Appl. Environ. Microbiol., 73: 4279–4285.

Tran, L., Nunan, L., Redman, R. M., Mohney, L. L., Pantoja, C. R., Fitzsimmons, K. and Lightner, D.V. (2013). Determination of the infectious nature of the agent of acute hepatopancreatic necrosis syndrome affecting penaeid shrimp. Disease of Aquatic Organisms, 105: 45-55.

Tran, T. H. T., Yanagawa, H., Nguyen, K. T., Hara-Kudo, Y., Taniguchi, T. and Hayashidani, H. (2018). Prevalence of *Vibrio parahaemolyticus* in seafood and water environment in the Mekong Delta, Vietnam. Journal of Veterinary Medical Science, *80*(11): 1737-1742.

Traore, O., Martikainen, O., Siitonen, A., Traore, A. S., Barro, N. and Haukka, K. (2014). Occurrence of *Vibrio cholerae* in fish and water from a reservoir and a neighboring channel in Ouagadougou, Burkina Faso*. J Infect Dev Ctries,* 8: 1334-1338.

Tsai, E. R., Tintu, A. N., Demirtas, D., Boucherie, R. J., de Jonge, R. and de Rijke, Y. B. (2019). A critical review of laboratory performance indicators. Critical Reviews in Clinical Laboratory Sciences, 56(7): 458-471.

Uchida, K., Konishi, Y., Harada, K., Okihashi, M., Yamaguchi, T., Do, M.H.N., Thi Bui, L., Duc Nguyen, T., Do Nguyen, P., Thi Khong, D. and Thi Tran, H. (2016). Monitoring of antibiotic residues in aquatic products in urban and rural areas of Vietnam. Journal of Agricultural and Food Chemistry, 64(31): 6133-6138.

Vazquez-Morado, L. E., Robles-Zepeda, R. E., Ochoa-Leyva, A., Arvizu-Flores, A. A., Garibay-Escobar, A., Castillo-Yañez, F. and Lopez-Zavala, A. A. (2021). Biochemical characterization and inhibition of thermolabile hemolysin from *Vibrio parahaemolyticus* by phenolic compounds. PeerJ., 9: e10506.

Venkateswarlu, V., & Venkatrayulu, C. (2019). Prevalence of disease problems affecting shrimp *Litopenaeus vannamei* farming in Andhra Pradesh, India. Int. J. Fish. Aquat. Stud., 7(5): 275-279.

Vergel, J. C. V., Cabawatan, L. D. P., Madrona, V. A. C., Rosario, A. F. T., Tare, M. V. R., & Maningas, M. B. B. (2019). Detection of Taura Syndrome Virus (TSV) in *Litopenaeus vannamei* in the Philippines. The Philippines Journal of Fisheries, 26 (1): 8-14.

Vrancianu, C. O., Popa, L. I., Bleotu, C. and Chifiriuc, M. C. (2020). Targeting Plasmids to Limit Acquisition and Transmission of Antimicrobial Resistance. Front. Microbiol., 11:761

Wang, K., Kou, Y., Wang, M., Ma, X. and Wang, J. (2020a). Determination of nitrofuran metabolites in fish by ultraperformance liquid chromatography-photodiode array detection with thermostatic ultrasound-assisted derivatization. ACS omega, 5(30): 18887-18893.

Wang, X., Liu, J., Liang, J., Sun, H. and Zhang, X. H. (2020b). Spatiotemporal dynamics of the total and active *Vibrio* spp. populations throughout the Changjiang estuary in China. Environ. Microbiol., 22: 4438-4455

Wang, R., Zhong, Y., Gu, X., Yuan, J., Saeed, A. F. and Wang, S. (2015). The pathogenesis, detection, and prevention of *Vibrio parahaemolyticus*. Frontiers in microbiology, *6*: 144.

Wang, T.J., Sambrook, J., Fritsch, E.F. and Maniatis, T. (2011). DNA Technology, Plasmids Mechanisms and Isolation: A Novel Approach. 5th Edn. Cold Spring Harbor. NY: Cold Spring Harbor Institute and Laboratory (Manual and Approaches).

Watts, J. E., Schreier, H. J., Lanska, L. and Hale, M. S. (2017). The rising tide of antimicrobial resistance in aquaculture: sources, sinks and solutions. Marine drugs, 15(6): 158.

World Health Organization (WHO). (2022). Antibiotics resistance. Accessed April 21, 2022. https://www.who.int/news-room/fact-sheets/detail/antibiotic-resistance.

World Health Organization. (2019). Global Antimicrobial Resistance Surveillance System (GLASS): early implementation protocol for inclusion of *Candida* spp. (No. WHO/WSI/AMR/2019.4). World Health Organization.

Wright, G. D. (2010). Q&A: Antibiotic resistance: where does it come from and what can we do about it?. BMC biology, 8: 1-6.

Xie, T., Wu, Q., Zhang, J., Xu, X. and Cheng, J. (2017). Comparison of *Vibrio parahaemolyticus* isolates from aquatic products and clinical by antibiotic susceptibility, virulence, and molecular characterisation. Food Control, 71: 315-321.

Xing, J., Zhou, X., Tang, X., Sheng, X., & Zhan, W. (2018). *FlaC* supplemented with *VAA, OmpK* or *OmpR* as bivalent subunit vaccine candidates induce immune responses against *Vibrio anguillarum* in flounder (*Paralichthys olivaceus*). Vaccine, 36(10): 1316-1322.

Yano, Y., Hamano, K., Satomi, M., Tsutsui, I., Ban, M. and Aue-Umneoy, D. (2014). Prevalence and antimicrobial susceptibility of *Vibrio* species related to food safety isolated from shrimp cultured at inland ponds in Thailand. Food Control, 38: 30–36.

You, K. G., Bong, C. W. and Lee, C. W. (2016). Antibiotic resistance and plasmid profiling of *Vibrio* spp. in tropical waters of Peninsular Malaysia. Environmental monitoring and assessment, 188: 1-15.

Yu, Y. B., Choi, J. H., Kang, J. C., Kim, H. J. and Kim, J. H. (2022). Shrimp bacterial and parasitic disease listed in the OIE: A review. Microbial Pathogenesis, 166: 105545.

Yu, J.Y., Yang, N., Hou, Z.H., Wang, J.J., Li, T., Chang, L.R., Fang, Y. and Yan, D.C. (2021). Research progress on hosts and carriers, prevalence, virulence of infectious hypodermal and hematopoietic necrosis virus (IHHNV). Journal of Invertebrate Pathology, 183: 107556.

Yu, Y., Tang, M., Wang, Y., Liao, M., Wang, C., Rong, X., Li, B., Ge, J., Gao, Y., Dong, X. and Zhang, Z. (2023). Virulence and antimicrobial resistance characteristics assessment of *Vibrio* isolated from shrimp (*Penaeus vannamei*) breeding system in south China. *Ecotoxicology and Environmental Safety.* 252: 114615.

Yudiati, E. and Azhar, N. (2021). Antimicrobial susceptibility and minimum inhibition concentration of *Vibrio parahaemolyticus*, *Vibrio vulnificus* and *Vibrio harveyi* isolated from a white shrimp (*Litopenaeus vannamei*) pond. In IOP Conference Series: Earth and Environmental Science (Vol. 763, No. 1, p. 012025). IOP Publishing.

Zago, V., Zambon, M., Civettini, M., Zaltum, O. and Manfrin, A. (2017). Virulence-associated factors in *Vibrio cholerae* non-O1/non-O139 and *V. mimicus* strains isolated in ornamental fish species. Journal of Fish Diseases, 40(12): 1857-1868.

Zha, F., Pang, R., Huang, S., Zhang, J., Wang, J., Chen, M., Xue, L., Ye, Q., Wu, S., Yang, M. and Gu, Q. (2023). Evaluation of the pathogenesis of non-typical strain with α-hemolysin, *Vibrio parahaemolyticus* isolated from Chinese seafood through comparative genome and transcriptome analysis. Marine Pollution Bulletin, 186: 114276.

Zhao, X., Yu, Z., & Ding, T. (2020). Quorum-sensing regulation of antimicrobial resistance in bacteria. Microorganisms, 8(3): 425.

Zhang, Z.H., Jhaveri, D.J., Marshall, V.M., Bauer, D.C., Edson, J., Narayanan, R.K., Robinson, G.J., Lundberg, A.E., Bartlett, P.F., Wray, N.R. and Zhao, Q.Y. (2014). A comparative study of techniques for differential expression analysis on RNA-Seq data. PloS one, 9(8): 103207.

Zhang, D., Xu, D. H., Qiu, J., Rasmussen-Ivey, C. R., Liles, M. R. and Beck, B. H. (2017). Chitin degradation and utilization by virulent *Aeromonas hydrophila* strain ML10-51K. Archives of Microbiology, 199(4): 573-579.

Zhang, X. H., He, X. and Austin, B. (2020). *Vibrio harveyi*: a serious pathogen of fish and invertebrates in mariculture. Marine life science & technology, 2: 231-245.

Zhang, X., Sun, J., Chen, F., Qi, H., Chen, L., Sung, Y.Y., Huang, Y., Lv, A. and Hu, X. (2021). Phenotypic and genomic characterization of a *Vibrio parahaemolyticus* strain causing disease in *Penaeus vannamei* provides insights into its niche adaptation and pathogenic mechanism. Microbial genomics, *7*(5): 000549.

Zhong, Y., Chen, J., Huang, C., Jin, H., Huang, J., Zhao, L., Geng, Y., Wang, G. and Qian, X. (2023). Isolation, Identification, and Pathogenicity of Pathogens from *Litopenaeus vannamei* With Acute Hepatopancreatic Necrosis Disease. Pakistan J. Zool., 1-12.

Zughaier, S.M. and Cornelis, P. (2018). Editorial: Role of Iron in Bacterial Pathogenesis. Front. Cell. Infect. Microbiol., 8: 344.

Zulkifli, Y., Alitheen, N. B., Raha, A. R., Yeap, S. K., Son, R. and Nishibuchi, M. (2009). Antibiotic resistance and plasmid profiling of *Vibrio parahaemolyticus* isolated from cockles in Padang, Indonesia. International Food Research Journal, 16(1).

Zulkifli, Y., Alitheen, N. B., Raha, A. R., Yeap, S. K., Son, R. and Nishibuchi, M. (2009). Antibiotic resistance and plasmid profiling of *Vibrio parahaemolyticus* isolated from cockles in Padang, Indonesia. International Food Research Journal, 16(1).