A review of mollusks farming in Chile

Barile J.[1]; Carreño E.[2]; De los Ríos-Escalante P.[3,4,*]

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Abstract

The mollusks farming is the second important aquaculture activity in production in Chile, although it is not an important foreign exchange source in comparison to salmon farming, it is an important economic activity at local scale for fishing villages, mainly in the South of Chile, and many of the production is destined to local consumption, and an important fraction is destined to exportation. The present study does a revision of mollusks farming in Chile. The mollusks culture began at least 150 years with intents for culture local oysters (*Ostrea chilensis*) and Chilean mussels (*Mytilus chilensis*) mainly in Southern Chile, and in the last six decades, increased the experimental and low scale industrial scale farming in the north of Chile for local oysters (*Ostrea chilensis*), giant mussels (*Choromytilus chorus*), Northern Chilean scallop (*Argopecten purpuratus*) and ribbon mussel (*Aulacomya ater*) as native species, and also were introduced species such as Pacific oyster (*Crassostrea gigas*) and Abalones (*Haliotis discus hanai* and *H. rufescens*), nevertheless the culture of these last species are regulated because these are introduced species that can have effects on ecosystems. The main cultured species is M. chilensis with 96.6 %, followed by *A. purpuratus* with 1.9 %, and the other species have the 1.5 % included other species. The main zone with mollusks culture is in inner seas in Southern Chile.

Keywords: Aquaculture, bivalve farming, mussel farming, Chile.

1-Departamento de Agropecuarias y Acuícolas, Facultad de Recursos Naturales, Universidad Católica de Temuco, Casilla 15-D, Temuco, Chile.
2-Instituto Tecnológico de la Universidad Católica de Temuco, Casilla 15-D, Temuco, Chile.
3-Departamento de Ciencias Biológicas y Químicas, Facultad de Recursos Naturales, Universidad Católica de Temuco, Casilla 15-D, Temuco, Chile.
4-Núcleo de Estudios Ambientales UC Temuco, Casilla 15-D, Temuco, Chile.
*Corresponding author's Email: prios@uct.cl

Introduction

The bivalve culture in Chile is the second main important activity in local aquaculture, that is developed mainly in the north of Chile between Antofagasta and Coquimbo regions where are cultured mainly Chilean scallops (*Argopecten purpuratus*) and Pacific oyster (*Crassostrea gigas*), whereas the other zone with main bivalve farming is located between Araucania and Lakes regions where are cultured mainly mussels such as Chilean mussel (*Mytilus edulis*), ribbon mussel (*Aulacomya ater*), giant mussel (*Choromytilus chorus*), Pacific oyster (*C. gigas*) and Chilean oyster (*Crassostrea gigas*) (Sernapesca, 2023).

The bivalve farming in Chile began in 1960 decades with first experiences in South of Chile with *M. edulis*, *A. ater*, *C. chorus*, and *C. gigas*, whereas at North of Chile began with *A purpuratus* (Tomicic & Barile, 1981; Uriarte, 2008). These intents were enhanced due internal politics of increase productive economical activities in Chile, that involved alternative activities such as fisheries and aquaculture (Uriarte, 2008).

North of Chile

The first intents were conducted by Chilean government for research on *A. purpuratus* culture in Atacama and Coquimbo regions with the aim of get a massive culture (Uriarte, 2008). Whereas in Antofagasta region, were conducted experimental farmings at low scale of *O. chilensis* (Tomicic & Barile, 1981) *A. ater* and *S. algosus* (De los Ríos-Escalante, pers. obs.). Also, the last culture intents with native species involved the local squid *Octopus mimus* that were conducted for different farmed at adults and juvenile culture at experimental levels and applied reproductive biology (Zúñiga *et al*., 1994, 1995; Castro *et al*., 2001; Olivares *et al*., 2001).

Simultaneously to the experiences conducted in Atacama and Coquimbo regions with *A. purpuratus* (Uriarte, 2008), in Antofagasta region were conducted observations on basic biology and management of native stocks (Araya *et al*., 1993; Avendaño *et al*., 2001, 2008; Avendaño & Le Pennec, 1998; Avendaño & Cantillanez, 2005, 2006, 2008; Cantillanez *et al*., 2005; Thebault, 2008), as well as microbiological topics associated to wild and farmed scallops (Riquelme *et al*., 1995, 1996a,b, 1997, 2001; Araya *et al*., 1999; Jorquera *et al*., 2001; Avendaño *et al*., 2001; Avendaño-Herrera *et al*., 2001, 2002; Urtubia *et al*., 2023). The scallop farmers in north of Chile are mainly small businessmen and fishermen cooperatives (Molina *et al*., 2012; Subpesca, 2023).

South of Chile

The mollusks culture as economic activity is developed mainly in South of Chile between Araucania and Lakes regions, where the main activities are the mussel farming, being the most important the Chilean mussel farming (*M. edulis*) and in minor scale with giant mussel (*C. chorus*), ribbon mussel (*A. ater*), giant oyster (*C.*

gigas) and Chilean oyster (*O. chilensis*), (Barile *et al*., 2022; Subpesca, 2023).

The *M. chilensis* culture is the main activity in Lake's regions, where it is developed mainly by small businessmen and fishermen cooperatives, but in spite of this aquaculture activity is extensive, it is the second main aquaculture activity in Chile (Molina *et al*., 2012; Subpesca, 2023). An interesting situation of bivalve farming occurs in Araucania region where in small estuaries are farmed *C. gigas* and *C. chorus* (Subpesca, 2023).

Also, the potential for bivalve farming in South of Chile involved experimental studies with *A. purpuratus* with the aim of introducing this species for local aquaculture (Farias & Uriarte, 2001; Cancino *et al*., 2003; Uriarte *et al*., 2001, 2004).

Also, there are recent research activities for octopus culture (Farías *et al*., 2020; Espinoza *et al*., 2021a, b) and abalones (Mardones *et al*., 2013, 2015), but these are only experimental studies that do not reach pilot or minor productive scale.

Current situation

The statistics of aquaculture production in Chile reveals that mollusks, specifically mussels farming is the second most important activity in Chilean aquaculture, but there is more potentiality for develop other kind of bivalve culture, and there are necessary more applied studies for culture other kind of mollusks with advanced studies such as abalones and octopus. Also, there are necessary more long-term management and politics for incentive the aquaculture activities with non-salmonid species, because there are many potentialities on technical and economic view point for incentive mollusks farming. Nevertheless, there are limitations such as such as oceanographic conditions specifically ENSO phenomena with consequences in environmental conditions.

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References

Araya, P., Pozo, A., Avendaño, M., and Escribano, R., 1993. Dinamica de alimentacion de individuos *Argopecten purpuratus* L. en condiciones de laboratorio. *Revista de Biologia Marina*, 28: 313-329

Araya, R.A., Jorquera, M.A., and Riquelme, C.E., 1999. Asociación de bacterias al ciclo de vida de *Argopecten purpuratus*. *Revista Chilena de Historia Natural*, 72: 261-271.

Avendaño, M., and Le Pennec, M., 1998. Presencia de células auxiliares en la gametogénesis del ostión del norte, *Argopecten purpuratus* (Lamarck, 1819), (Mollusca, Bivalvia, Pectinidae). *Estudios Oceanologicos*, 17, 13-16.

Avendaño, M., Le Pennec, M., and Cantillanez, M., 2001. Anormalidades en larvas de *Argopecten purpuratus* (Lamarck, 1819) (Mollusca:

Pectinidae), uno de los problemas en la producción artificial de semilla. *Estudios Oceanologicos*, 20, 33-42.

Avendaño, R. E., Riquelme, C. E., Escribano, R., and Reyes, N., 2001. Sobrevivencia y crecimiento de post-larvas de *Argopecten purpuratus* (Lamarck, 1819) en Bahía Inglesa, Chile: efectos del origen, distribución en la bahía y bacterioflora larval. *Revista Chilena de Historia Natural,* 74: 669-679. DOI:10.4067/S0716-078X2001000300012

Avendaño, M., and Cantillánez, M., 2005. Crecimiento y estructura demográfica de *Argopecten purpuratus* en la reserva marina La Rinconada, Antofagasta, Chile. *Ciencias marinas*, 31: 491-503.

Avendaño, M., Cantillánez, M., and Peña, J., 2006. Effect of immersion time of cultch on spatfall of the scallop *Argopecten purpuratus* (Lamarck 1819) in the Marine Reserve at La Riconada, Antofagasta, Chile. *Aquaculture International*, 14: 267-283. DOI:10.1007/s10499-005-9033-y

Avendaño, M., Cantillánez, M., Thouzeau, G., and Peña, J.B., 2008. Artificial collection and early growth of spat of the scallop Argopecten purpuratus (Lamarck, 1819), in La Rinconada Marine Reserve, Antofagasta, Chile. *Scientia Marina*¸71: 197-205. DOI: /10.3989/scimar.2007.71n1197

Avendano, M., Cantillánez, M., and Thouzeau, G., 2008. Effects of water depth on survival and growth of *Argopecten purpuratus* (Lamarck, 1819) spat in northern Chile. *Aquaculture International*, 16: 377-391. DOI:10.1007/s10499-007-9151-9

Avendaño, M., and Cantillánez, M., 2008. Aspectos biológicos y poblacionales de *Argopecten purpuratus* en la reserva marina La Rinconada: contribución para su manejo. Estado actual del cultivo y manejo de moluscos bivalvos y su proyección futura: factores que afectan su sustentabilidad en América Latina. Taller Técnico Regional de la FAO, 20-24.

Avendaño-Herrera, R.E., Dekovic, M., and Riquelme, C.E., 2001. Establecimiento de bacterias benéficas en el tracto digestivo y gónada de adultos de *Argopecten purpuratus* (Lamarck 1819) en cultivo masivo. *Revista de Biología Marina y Oceanografía*, 36: 31-41. DOI: 10.4067/S0718-19572001000100004

Avendaño-Herrera, R.E., Riquelme, C.E., and Silva, F., 2002. Utilización de biopelículas bacterianas en el asentamiento de larvas de *Argopecten purpuratus* (Lamarck 1819) en un hatchery comercial. *Revista De Biología Marina Y Oceanografía*, 37: 35-41. DOI:10.4067/S0718-19572002000100006

Barile, J., Rivas, G., Vega, R., and De los Ríos-Escalante, P., 2022. Biological control of incrusting organisms and sediments in Chilean oyster cultures. *Brazilian Journal of Biology,* 82:

236182. DOI:10.1590/1519-6984.236182

Cancino J.M., Uriarte, I., Navarro, J., Gajardo, G., Farías, A., Nevejan, N., 2003. Effects of lipid emulsions and temperature on the hatchery performance of Chilean scallop *Argopecten purpuratus* (Lamarck 1819) larvae. *Aquaculture Research*, 34: 899-902. DOI:10.1046/j.1365-2109.2003.00889.x

Cantillanez, M., Avendaño, M., Thouzeau, G., and Le Pennec, M., 2005. Reproductive cycle of *Argopecten purpuratus* (Bivalvia: Pectinidae) in La Rinconada marine reserve (Antofagasta, Chile): response to environmental effects of El Niño and La Niña. *Aquaculture*, 246: 181-195. DOI: 10.1016/j.aquaculture.2004.12.031

Castro, H., Olivares, A., Quintana, A., and Zúñiga, O., 2001. Descripción del estado embrionario y paralarva de *Octopus mimus* (Gould, 1852) (Mollusca: Cephalopoda) en cautiverio. *Estudios Oceanológicos*, 21: 13-25

Farías, A, Hernández, J, Torres, C, Espinoza, V., Viana, M.T., Navarro, J.C., and Uriarte, I., 2020. Assessment of diet and temperature on the overall performance of Patagonian red octopus (*Enteroctopus megalocyathus*, Gould) paralarvae. *Aquaculture Nutrition*, 26: 1275–1288. DOI:10.1111/anu.13083

Espinoza, V., Brokordt, K., Farías, A., Romero, A. and Uriarte, I. 2021a, Assessment of culture density and prey availability for the management of cannibalism in paralarvae of Patagonian red octopus *Enteroctopus megalocyathus*. *Aquaculture Research*, 52: 4629-4637 DOI:10.1111/are.15297

Espinoza, V, Farías, A, and Uriarte, I. Characterization of cannibalism in early paralarvae of Patagonian red octopus, *Enteroctopus megalocyathus* (Gould, 1852), grown in a controlled environment**.** *Journal of World Aquaculture Society*, **52**: 475–481. DOI:10.1111/jwas.12738

Farías, A., and Uriarte, I., 2001. Effect of microalgae protein on the gonad development and physiological parameters for the scallop *Argopecten purpuratus* (Lamarck, 1819). *Journal of Shellfish Research*, 20:97-105.

Mardones, A., Augsburger, A., Vega, R., and De los Ríos-Escalante, P., 2013. Growth rates of *Haliotis rufescens* and *Haliotis discus* hannai in tank culture systems in southern Chile (41.5ºS). *Latin American Journal of Aquatic Research*, 41: 959-967. DOI:10.3856/vol41-issue5-fulltext-14

Mardones, A., Cordero, R., Augsburger, A., and De los Ríos-Escalante, P., 2015. Desarrollo del ensilado del alga *Gracilaria chilensis* para la alimentación del abalón rojo *Haliotis rufescens*. *Latin American Journal of Aquatic Research*, 43: 295-303. DOI:10.3856/vol43-issue2-fulltext-4

Molina, R., Cerda, R., González, E., and Hurtado, F., 2012. Simulation model of the scallop (*Argopecten purpuratus*) farming in northern Chile: some applications in the decision-making

process. *Latin American Journal of Aquatic Research*, 40: 679-693. DOI:103856/vol40-issue3-fulltext-16

Olivares, A., Zamora, M., Portilla, and P., Zúñiga, O., 2001. Estudio histológico de la ovogénesis y maduración ovárica en *Octopus mimus* (Cephalopoda; Octopidae) de la II Región de Chile. *Estudios Oceanológicos*, 20: 13-22-

Riquelme, C., Hayashida, G., Toranzo, A. E., Vilches, J., and Chavez, P., 1995. Pathogenicity studies on a *Vibrio anguillarum*-related (VAR) strain causing an epizootic in *Argopecten purpuratus* larvae cultured in Chile. *Diseases of Aquatic Organisms*, 22: 135-141. DOI:10.3354/dao022135

Riquelme, C., Toranzo, A. E., Barja, J. L., Vergara, N., and Araya, R., 1996a. Association of *Aeromonas hydrophila* and *Vibrio alginolyticus* with larval mortalities of scallop (*Argopecten purpuratus*). *Journal of Invertebrate Pathology*, 67: 213-218. DOI: 10.1006/jipa.1996.0035

Riquelme, C., Hayashida, G., Araya, R, Uchida, A., Satomi, M., and Ishida, Y., 1996b. Isolation of a native bacterial strain from the scallop *Argopecten purpuratus* with inhibitory effects against pathogenic vibrios. *Journal of Shellfish Research*, 15: 369-374.

Riquelme, C., Araya, R., Vergara, N., Rojas, A., Guaita, M., and Candia, M., 1997. Potential probiotic strains in the culture of the Chilean scallop *Argopecten purpuratus* (Lamarck, 1819). *Aquaculture*, 154: 17-26. DOI:10.1016/S0044-8486(97)00043-4

Riquelme, C.E., Jorquera, M. A., Rojas, A.I., Avendaño, R.E., and Reyes, N., 2001. Addition of inhibitor-producing bacteria to mass cultures of *Argopecten purpuratus* larvae (Lamarck, 1819). *Aquaculture*, 192: 111-119. DOI:10.1016/S0044-8486(00)00461-0

Servicio Nacional de Pesca y Acuicultura-Chile, 2023 [Fisheries and Aquaculture National Service - Chile] http://www.sernapesca.cl/ (Visited 30th October 2023) Subpesca-Subsecretaría de Pesca [Fisheries subsecretary].

Thébault, J., Thouzeau, G., Chauvaud, L., Cantillánez, M., and Avendaño, M., 2008. Growth of *Argopecten purpuratus* (Mollusca: Bivalvia) on a natural bank in Northern Chile: sclerochronological record and environmental controls. *Aquatic Living Resources*, 21: 45-55. DOI: 10.1051/alr:2008021

Tomicic, J., and Barile, J., 1981. Manual de guía para el cultivo de la ostra en la 2ª Región de Chile. Universidad de Antofagasta, 73P.

Uriarte, I., Farías, A., and Castilla, J.C., 2001. Effect of antibiotic treatment during larval development of the Chilean scallop *Argopecten purpuratus*. *Aquaculture Engineering*, 25: 139-147. DOI:10.1016/S0144-8609(01)00078-4

Uriarte, I., Farías, A., Hernández, J., Schäfer, C., and Sorgeloos, P., 2004. Reproductive conditioning of Chilean scallop (*Argopecten purpuratus*) and

the Pacific oyster (*Crassostrea gigas*): effects of enriched diets. *Aquaculture*, 230: 349-357. DOI:10.1016/S0044-8486(03)00419-8

Uriarte, I. 2008. Estado actual del cultivo de moluscos bivalvos en Chile. En A. Lovatelli, A. Farías e I. Uriarte (eds). Estado actual del cultivo y manejo de moluscos bivalvos y su proyección futura: factores que afectan su sustentabilidad en América Latina. Taller Técnico Regional de la FAO. 20–24 de agosto de 2007, Puerto Montt, Chile. FAO Actas de Pesca y Acuicultura. No. 12. Roma, FAO. pp. 61–75.

Urtubia, R., Miranda, C.D., Rodríguez, S., Dubert, J., Barja, J.L., and Rojas, R., 2023. First Report, Characterization and pathogenicity of *Vibrio chagasii* isolated from diseased reared larvae of Chilean scallop, *Argopecten purpuratus* (Lamarck, 1819). Pathogens, 12: 183. DOI:10.3390/pathogens12020183

Zúñiga, O., Olivares, A., and Retamales, E., 1994. Escala de madurez sexual de *Octopus* de la II región, Chile. *Estudios Oceanológicos*, 13: 89-91.

Zúñiga, O., Olivares, A., and Ossandon, L., 1995. Influencia de la luz en la maduración sexual de hembras de *Octopus mimus*. *Estudios Oceanologicos*, 14: 75-76.