Bull. Korean Fish. Soc. 12(4), 287~292, 1979 韓水誌 12(4), 287~292, 1979

OYSTER SETTING IN THE RESTINGA LAGOON IN VENEZUELA

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베네주엘라國 RESTINGA湖의 굴 採苗

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南美 Venezuela國에 있는 면적 약 26.6 km^2, 수심 약 6m의 함수湖인 Restinga Lagoon에서 1979년 9월, 10월 2개월간 그곳 自然産 굴인 *Crassostrea rhizophorae*의 採苗試驗을 실시하였다. 採苗成績은 St.2(Fig .2)에서 우수하여 채묘기 100 cm^2當 약 45個体가 발견되었는데, 부착치패는 潮差범위인 약 30 cm중 중간 10 cm 부분에서 가장 많았고 低潮線下에선 각종 부착생물이 다량 부착되었을뿐 굴 稚貝는 거의 발견되지 않았다.

따라서, Restinga Lagoon에서의 채묘適地는 St.2가 적합하였고 채묘기 설치위치는 약 4시간 露出線인 低潮線위 15~10 cm가 最適이었다.

INTRODUCTION

One of most important criteria for successful oyster farming is the correct timing and placing of the collectors for setting of oyster seeds (Nikolic *et al.*, 1976; Shaw, 1968). Many studies have been made on the setting behavior of oyster larvae throughout the world. Most of these have been field observations directed toward the prediction of setting periods, intensity, zone of distribution and use of substrates to determine favorable situations for setting and survival.

The mangrove oyster (*Crassostrea rhizophorae* Guilding) is found in the coastal marine waters of the various countries bordering the Caribbean Sea and adjacent waters. Since studies on the biology of this edible oyster and the possible expansion of commercial activities were discussed by Mattox (1949), a system for culturing has been investigated in several countries, but few of them obtained satisfactory results. The oyster industry in Venezuela is almost non-existent though the feasibility of culture through field investigations has been discussed and recommended (Velez, 1972 and 1968; Carvajal, 1962).

The Restinga Lagoon, one of big lagoons in Venezuela, has been noticed for its edible oysters since early 1940's (Mosqueira, 1943) but only Angell (1972) has experimented with oyster setting. He found spawning and setting of oyster larvae occurred throughout the year, but intensity of set and larvae counts were most intense during cooler months, January to May.

To date, small-scale culture in this lagoon has been experimented from time to time but it has not been successful yet. Failure was mainly due to the abundance of fouilng organisms. Therefore, we applied a method by using intertidal system, which is a sort of mixture of two

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methods, one by Nikolic *ed al.* (1976) in Cuba and the other by Marshall (1968) in North Carolina, the United States of America.

DESCRIPTION OF AREA

The Restinga Lagoon, which is located in the central-northern coast of the Margarita Island, is hypersaline and its area is ca. 26.6 km^2. Waters are exchanged through a narrow mouth which opens in the southern coast of the Island (Fig. 1). The depth of the central part of the lagoon varies 1—6*m*. Mean temperature of superficial waters is 27.7°C (26.5—29.6°C) and salinity is 38.6 ppt (36.4—39.4ppt). The precipitation is low, approximately 274*mm* per year (Angell, 1972) and there is no river.

Natural existence of oyster is more dense in waters of less salinity of the central area of the lagoon, where setting is encountered on aerial roots, terrestrial roots, and terminal branches of the mangrove tree. Vertical distribution is restricted to a narrow band, approximately 15—20*cm* within the daily tidal range, that is, from 10—15*cm* to 25—35*cm* above low tidal level. Presence of vigorous growth of invertebrates below the low tidal level is characteristics.

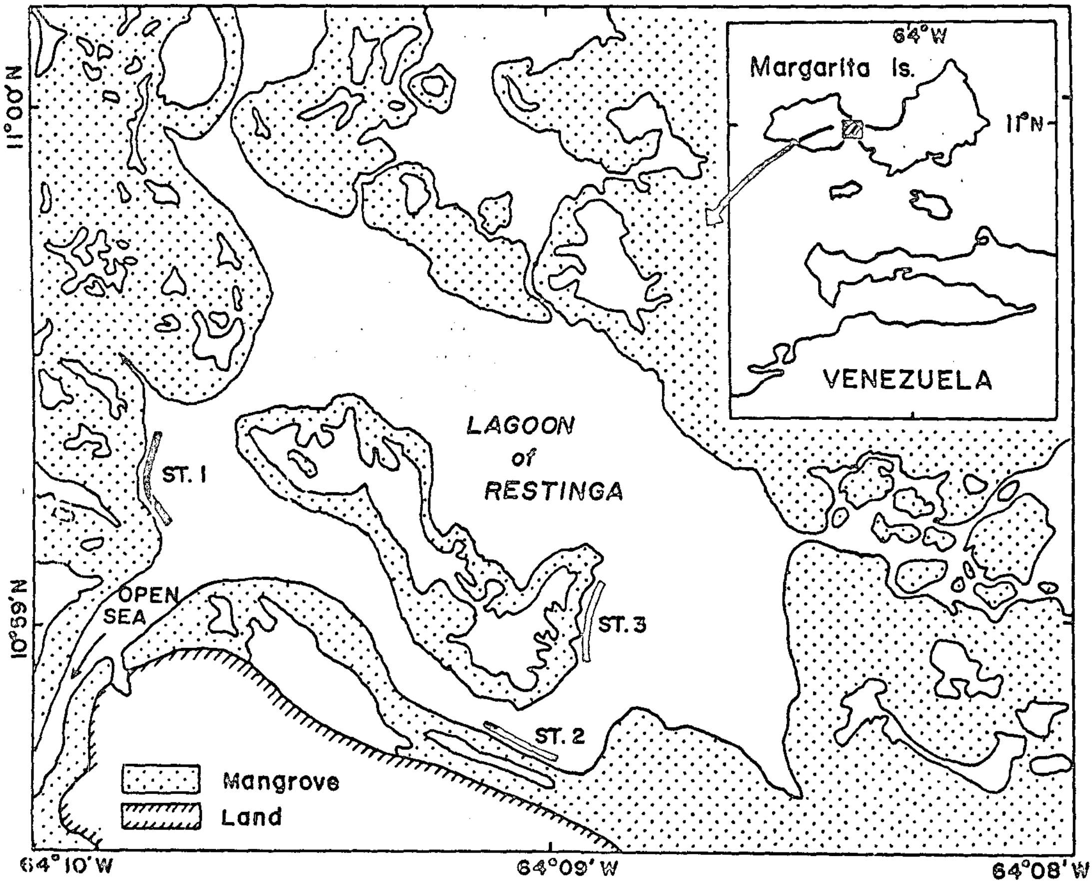

Fig. 1. Map showing the sampling stations.

METHODS AND MATERIALS

Three stations were fixed where natural oysters was abundant (Fig. 1), and the investigation was carried out for a two month period, September and October 1979.

Planktonic oyster larvae were monitored weekly. A Kitahara net used for sampling was a conical type of 30*cm* in diameter and double X 13 nylon gauge. Each sample consisted of a vertical net haul from one meter depth to the surface water level, and it was repeated five times at each station. Total number of larvae was estimated by using a microscope, and identification of larvae followed Martines (1962).

Oyster setting was sampled by using two different collectors; plastic box, and asbestos plate. At each station, 5 collectors each were placed vertically in accordance with water level, that is, the upper halves of them were suspended above the low tidal level and the lower halves were continually immersed. After 30 days from the time when the collectors were suspended, they were removed and examined for attached spats. All oysters were counted on 100cm^2 of surface.

Ancillary data were recorded between ten and eleven o'clock in the morning. Water temperature was measured with a conventional thermometer and salinity was cheked with an American Optical Goldberg T/C reflectometer.

RESULTS AND DISCUSSION

Temperature and salinity

A maximum temperature of superficial waters in the Restinga Lagoon during the experimental period was 30.3°C, and maximum salinity was 40.0ppt. There was no big differences of temperature and salinity between surface and bottom waters, presumable due to the shallow depth (1—6*m*). Mean temperature was 29.43 °C, and mean salinity was 37.70ppt (Table 1).

In tropical waters, planktonic oyster larvae and settlement of larvae occur almost throughout the year (Velez, 1972 and 1968; Angell, 1972; Mattox, 1949). Although Mattox (1949) found there was no peak of larvae set, Angel (1972) reported that intensity of set and larvae counts were most intense during cooler months, January to May. Velez (1972) found the peak existed in the hot season, September to November, and he added that a minimum of larval settlement occurred in January to March. But from his other experiment done in the same area (Velez, 1968), he reported there were two peaks, during the three months from April to June and in September. Those experiments (Angell, 1972; Velez, 1972 and 1968) were done in the north-eastern areas of Venezuela, though they conducted them in different areas.

In Cocineta Lagoon, which is located in the north-western part of Venezuela, Yoo et al. (1976) found there were more larvae during April and May than from January to March.

Table 1. Temperature and salinity in the superficial waters in the Restinga Lagoon in September and October 1979

Date		Temp., °C			Salinity, ppt		
		ST.1	ST.2	ST.3	ST.1	ST.2	ST.3
Sept.	14	29.0	28.5	28.4	36.5	37.7	37.0
	21	30.1	30.3	30.2	36.2	36.8	36.5
Oct.	2	29.3	29.3	29.2	37.7	39.5	39.0
	9	29.4	29.3	29.9	38.1	37.5	40.0
	16	29.2	29.6	29.8	38.0	37.0	38.0
Mean		29.4	29.4	29.5	37.3	37.7	38.1

So, actually, temperature would not be a major regulating factor of mass spawning in tropical waters where temperature stays around 30.0°C throughout the year. Salinity does not seem a direct factor (Velez, 1972) either.

Planktonic larvae and spat count

The number of planktonic larvae (umbo and full grown stages together) per net haul (ca. 330L.) was 28-53. The maximum number was 89 at station 2 on September 14, and the means were 31, 53, and 30 at stations 1, 2, and 3, respectively in September and 28, 31, and 29 at stations 1, 2, and 3, respectively in October (Table 2).

Table 2. Numners of planktonic larvae (umbo and full grown stages) per net haul (330 L.) in the Restinga Lagoon in September and October 1979

Date	ST. 1			ST. 2			ST. 3		
	U	F	T	U	F	T	U	F	T
Sept. 14	31	8	39	75	14	89	40	5	45
19	41	3	44	48	10	58	29	3	31
21	9	2	11	8	3	11	12	1	13
Total			94			158			89
Oct. 2	6	2	8	23	3	26	5	1	6
9	2	—	2	3	—	3	14	—	14
16	54	21	75	47	17	64	50	17	67
Total			85			93			87

U: Umbo stage. F: Full grown stage. T: Total. —: None.

Table 3. Spat counts per unit area (100 cm^2) on the surface of collectors at the tidal zone* in the Restinga Lagoon in September and October 1979.

Sample number	Sept. 5—Oct. 2			Sept. 14—Oct. 16		
	ST. 1	ST. 2	ST. 3	ST. 1	ST. 2	ST. 3
1	12	82	5	4	41	8
2	1	43	13	14	60	12
3	21	21	4	7	37	9
4	8	50	7	6	33	6
5	5	16	14	5	53	14
Total	47	212	43	46	224	49
Mean	10	43	9	9	45	10

* Almost no spats were found on the collectors continually immersed.

Spat count per unit area (100 cm^2) was 9—45. The maximum spat count was 82 at station 2 and the means were 10, 43, and 9 at stations 1, 2, and 3, respectively during the first experiment carried out from September 5 to October 2, and the means during the second experiment carried out from September 14 to October 16 were 9, 45, and 10 at stations 1, 2, and 3, respectively (Table 3).

Difference of spat counts between different materials was not significant, but vertical difference in accordance with airing was significantly different; that is, collectors in the tidal zone was good, especially between 15*cm* and 10*cm* above the low tidal level, and almost no spats were found on collectors continually immersed.

In terms of culture of the mangrove oyster, Cuba obtained a fruitful result by using the mangrove branch for spat collectors (Nikolic *et al.*, 1976), and it was found that mussel shell was the best collector in Venezuela (Velez, 1968) but, unfortunately, it was impossible to get both materials because cutting mangrove branches was prohibited and gathering the shell was not easy in Margarita Island where the Restinga Lagoon is located.

Spat count in the Restinga Lagoon was ca. 40—50 per 100*cm*² at station 2 and it was a reasonable number. Landers (1968) found that a spat count of 10—15 per shell would be more realistic to allow for proper growth. It can be said that a spat count of ca. 35 per 100*cm*² would be good for setting ground in terms of commercial culture. Velez (1972) found ca. 70 per 100*cm*² in Mochima Bay in Venezuela.

A problem is, however, the fouling organisms. The mangrove oyster's life is very hazardous with many predators and competitors living among the mangrove branches where the oysters attach and develop (Mattox, 1949). Almost no oyster spats were found on the collectors continually immersed; perhaps for the same reason as Marshall (1968) found in North Carolina in the United States. Suspension of shells with attached spats in intertidal and subtidal zones of high salinity areas indicate that, in such areas, fouling organisms completely cover oysters that are continually immersed.

The best way to get good spat without foulling organisms in high salinity areas is that the collector should be placed where it is able to be in the air for 4 hours per day (Marshall, 1968). Therefore, to get good spats in this lagoon is presumed to suspend the collectors at 15—10*cm* zone above the low tidal level. It is the range of airing for between 4 *hr* 20*min* and 3 *hr* 40*min*

CONCLUSION

(1). Temperature and salinity did not seem to be regulatory factors in oyster larval distribution and spat count in the Restinga Lagoon.

(2) Number of planktonic larvae (umbo and full grown stages) was found ca. 40 per net haul (ca. 330 L.), and spat count was found ca. 45 per 100*cm*² on the surface of the collectors at station 2.

(3) Number of planktonic larvae and spat count showed that it was a good time to get spats during September and October, and there were reasonable numbers for proper growth. The best place for oyster setting was presumed to be at station 2 and its vicinity.

(4) Vertical difference of spat counts was significant though there was little difference between materials. A good set was found on the collectors at the tidal zone, specially 15—10*cm* above the low tidal level. Almost no oyster spats were found on the collectors continually immersed and fouling organisms completely covered them. In high salinity waters as in the Restinga Lagoon, there is little promise for successful oyster culture unless artificial airing can be adapted so as to be practical.

ACKNOWLEDGEMENTS

This study was made possible by a grant from the government of the Republic of Korea, FAO, and La Salle Foundation of Natural Science in Venezuela.

We would like to express our appreciation to Hermano Gines, the president of La Salle Foundation, for encouragement, Dr. Jose Otaola for administrative help and Drs. Edward Harrison and Domenico Voltolina for helpful discussions and advice. We also wish to thank Mr. Antonio Bautista and students of Aquaculture Department, Institute of Marine Technological Education of La Salle, for assistance both in field and laboratory work.

REFERENCES

Angell, C. L. (1972): Maduracion gonadica y fijacion *Crassostrea rhizophorae* en una laguna hipersalina del nororiente de Venezuela. Mem. Soc. Ciene. Nat. La Salle 32(93), 215—240.

Carvajal, J. (1962): Ensayos sobre crecimiento y metodos de cultivo de ostiones comestibles *Crassostrea rhizophorae* Guilding en la Bahia de Mochima. Lagena 2, 24—30.

Landers, W. S. (1968): Oyster hatcheries in the Northeast. Proc. Oyster culture Workshop, July 11—13, 1967. Mar. Fish. Div., Georgia Game and Fish Comm. pp. 35—40.

Marshall, H. L. (1968): Three-dimensional oyster culture research in North Carolina. *Ibid.* pp. 62—66.

Martinez, R. (1962): Aspectos bioecologicos de la *Crassostrea rhizophorae* Guilding en Laguna Grande del Obispo (Golgo de Cariaco). Inst. Oceanogr., Univ. Oriente 24pp.

Mattox, N. T. (1949): Studies on the biology of the edible oyster, *Ostrea rhizophorae* Guilding in Puerto Rico. Ecol. Monogr. 19(4), 339—356.

Mosqueira, J. M. (1943) : Ostras y perlas en las costas Venezolanas. Soc. Ciene. Nat. La Salle, Caracas 52pp.

Nikolic, M., Bosch A. and S. Alfonso (1976): A system for farming the mangrove oyster (*Crassostrea rhizophorae* Guilding). Aquaculture 9, 1—18.

Shaw, W. N. (1968): Raft culture of oyster in the United States. Proc. Oyster culture Workshop, July 11—13, 1967. Mar. Fish. Div., Georgia Game and Fish Comm. pp. 5—31.

Velez, A. (1972): Fijacion de la larva de la ostra de los bancos naturales de Bahia de Mochima y Laguna Grande. Bol. Inst. Oceanogr., Univ. Oriente 11(2), 97—106.

Velez, A. (1968): Ensayos de cultivo del ostion *Crassostrea rhizophorae* Guilding en el oriente de Venezuela. Lagena 19 & 20, 11—20.

Yoo, S., C. Cho and M. Yoo (1976): On the seedling time of the mangrove oyster, *Crassostrea rhizophorae*, in the Lagoon of Cocineta in Venezuela. Bull. Korean Fish. Soc. 9(4), 281—285.