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Some Aspects of the Reproductive of Japanese Threadfin Bream (*Nemipterus japonicus* Bloch, 1791) Caught in the Area Around the Artificial Reef in the Pitu Sunggu Waters of the Makassar Strait

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ABSTRACT Japanese Threadfin Bream is a demersal fish commonly found around artificial reefs. Food availability in the artificial reef ecosystem is essential for the sustainability of this species. Hence, this research aimed to determine several aspects of bio-reproduction of Japanese Threadfin Bream caught in the artificial reef (bioreeftek). Samples were taken using handline fishing, twice a month (April-July 2020) in Pitu Sunggu Waters, Makassar Strait. The samples were observed for its reproduction aspects. The result showed that the Japanese Threadfin Bream fish caught have a balanced sex ratio between males and females, 1:1.03. The analysis of the gonad maturity stage obtained was II-IV, and the gonado somatic index ranged from 0.541-0.940 for males and 1.156-2.358 for females. The first mature Japanese Threadfin Bream size was 18.29 cm for males and 16.99 cm for females. The Japanese Threadfin Bream fish fecundity ranged between 35.042-42.061 eggs.

Keywords: Artificial reefs; Japanese Threadfin Bream; Makassar Strait; reproduction

INTRODUCTION

The Makassar Strait is one of the Indonesian Fisheries Management Area (FMA) 713, besides the Flores Sea, Bone Bay and the Bali Sea. FMA 713 have high potential, shown with a total production of 1.177.857 ton/year; which include 208.414 ton/year for small pelagic fish, 645.058 ton/year for big pelagic fish, 252.869 ton/year for demersal fish, 19.856 ton/year for reef fish, and 51.660 ton/year for Penaeid, Lobster, Crab, and Squid. The great potential of FMA 713, especially in the Makassar strait, is because the primer productivity is high, and the waters are connected directly to the Western part of the Pacific Ocean (Inaku, 2015). This condition caused the Makassar Strait to become a potential area with high productivity (Rasyid, 2011) as a nursery and growing area for many aquatic resources.

However, in FMA 713, most fish categories, such as small and big pelagic fish, reef fish, lobster and squid, are already classified as overexploitation (exploitation number ≥1). The demersal fish has been exploited 242.754.24 tonnes/year (96%). This number is classified as full exploitation (MMF, 2017).

The Japanese Threadfin Bream (*Nemipterus japonicus*) is a demersal fish (Amine, 2012; Oktaviyani, 2014) that could be caught in FMA 713. It also could be found in the Philippines and Japan (Russel, 1993), the Western part of Indo Pacific, Eastern Africa, Persia Cape, and the Red Sea (Kerdgari *et al*., 2013; Nettely, 2016). This species has high economic value (Brojo & Rian, 2002; Valinassab *et al*., 2006; Sutjipto *et al*., 2013; El-Alfawy *et al*., 2014; Rao *et al*., 2017). Japanese Threadfin Bream swim is known as fish that schooling (Kerdgari *et al*., 2009). These reasons could cause high catch intensity (Ghosh *et al*., 2015). Further, it will lead to catching pressure and cause the resource stock to decrease, and it also could change the population structure of the Japanese Threadfin Bream.

Many pieces of research have been conducted in the last decade related to the Threadfin Bream (*Nemipterus* sp.), including *N. japonicus* species. Some of the researches are age estimation and food habits of Japanese Threadfin Bream (*Nemipterus japonicus*) by Afshari *et al*. (2013), stock estimation and biological aspects by Amine (2012); ElHaweet (2013) and Sen *et al*. (2014), reproductive cycle, sexual maturity and fecundity of *Nemipterus fuscosus* (Rahman & Amira, 2021), relative abundance and population growth of male and female *Nemipterus furcosus* f (Amira *et al*., 2016), kidney accessories *Nemipterus japonicus* its relationship with gonadal maturation (El-Alfawy & Amal, 2014), potential sustainability of *Nemipterus japonicus* (Widagdo *et al*., 2019), population dynamics of the Japanese Threadfin Bream (*Nemipterus hexodon*) (Sutjipto *et al*., 2013) , Length-weight relationship of the Threadfin Bream (*Nemipterus* sp.) (Rapita *et al*., 2020), reproduction of the Japanese Threadfin Bream (*Nemipterus japonicus*) (Nettely *et al*., 2016; Rao *et al*., 2017), histology and ovarian development of *Nemipterus japonicus* (Kerdgari *et al*., 2013); reproductive biology of *Nemipterus randali* (Burcu & Sercan, 2021). However, these researches were done in the natural littoral area.

This research will focus on biology reproductive for Japanese Threadfin Bream catches around the bioreeftek ecosystem. Bioreeftek is one of the artificial reef models installed to create a new catching area. This research aims to analyze sex ratio, gonad maturity stage, gonad maturity index, first size of the first gonadal maturity and fecundity of the Japanese Threadfin Bream (*N. japonicus*). The results will be expected to become primary and vital information to determine the demersal fish management, especially in the conservation area open for catching.

MATERIALS AND METHODS

Materials

The material used in this research is a coolbox (Styrofoam) to collect the fish sample, a digital scale to measure body and gonad weight, a measurement kit (digital calipper) to measure the fish length and the gonad length, a section kit to perform surgery and to take the gonad samples, bottles sample to keep the gonads, Japanese Threadfin Bream gonad as samples, Gilson's solution to separate gonad from tissue.

Methods

Study site and sampling duration

This research was held from April to July 2020 in Makassar Strait, administratively located in Pitu Sunggu Village, Pangkajene Kepulauan Regency, South Sulawesi (Figure 1). Analysis of sample gonads was done at the Laboratory of State Agricultural Polytechnic of Pangkajene dan Kepulauan.

Figure 1. Sampling location (Pitu Sunggu Waters, Pangkajene Kepulauan Regency).

Sample collection

Making and arranging the artificial reefs (bioreeftek) is the first step to conducting this research, choosing a station and installing it on the spot where fishers usually catch the fish. The artificial reef was seated at a depth between 4 and 5 m. Several steps for sample collection and measurements: 1). Data collection was done twice a month and started after a month of installing the bioreeftek. It gives time for microorganisms to grow and be ready as feed for the fish; 2). The samples were taken using a handline by the fishers; 3). Samples were measured for the body length. Measurement of the length of the fish fork from the leading edge to the curve of the tail is carried out twice a month, namely in the first and third weeks; 4). Fish surgery and sex observation, gonadal maturity level; 5). Take the gonads on the front, middle, and back and then put them into a sample bottle containing Gilson's solution to calculate fecundity; 6). Observation of gonadal maturity based stage was (on size, shape and colour of the gonads), regarding the Cassie method modified by Effendi (1997). Gonads were preserved using Gilson's solution, which separates the tissue from the egg.

Fecundity determination

In calculating the fecundity, fish in maturing-spawning gonads were used (Stage III-V). Fecundity was calculated using sub-samples of gonad weight taken from the frontal part (anterior), middle (median), and backside (posterior) and placed in to sample bottle that was filled with Gilson's solution. Fresh ovaries that were just taken out of the fish's body and then the membrane that was still covered soaked in Gilson's solution or phosphate formalin. The soaking process of ovaries was done somehow to keep them wholly soaked. Therefore, the eggs would be hardened and could be easily separated from the membrane covering them (Kasmi *et al.*, 2017).

Table 1. Characteristics of gonad maturity level (Effendie, 1997).

Gonad maturity stage	Sex	
	Female	Male
I	The ovaries look like threads extending to the cavity of the front body. The colour is clear, and the surface is smooth.	Testicles look like threads with shorter, visible ends in the body's cavity. The colour is clear, and the surface is smooth.
II	The ovaries' sizes are bigger. Darker yellowish colour, the eggs are not seen with eyes.	Testicle sizes are bigger-whiter colour-milky. The shape is more precise than level I.
III	The ovaries are yellow. Morphologically, the eggs begin to show granules when seen with the eyes.	The surface of the testicles appears serrated. The colour is whiter; the testicles get more prominent. In the preserved state, it breaks easily.
IV	Ovaries are getting bigger. Eggs are yellow and easy to separate. The oil grains are not visible. Filling 1/2 - 2/3 of the abdominal cavity, the intestines are pressured.	It looks more apparent in level III, and the testes are getting thicker.
V	The ovaries are wrinkled, the walls are thick, and the remaining eggs appear near the release.	The back of the testicles is deflated, and the part near the release is still filled.

Data analysis

Sex ratio

$$x^2 = \sum_{=1} \left(\frac{(O_i - E_i)^2}{E_i}\right)$$

Where,
Oi = observation value (Observation),
Ei = expected value (Expectation).

The gonadosomatic index (GSI)

$$GSI = \frac{GW}{BW} \times 100\%$$

Where,
GSI = gonadosomatic index (%),
GW = gonad weight (g),
BW = is the body weight (g).

The mean size of the first maturity was determined using the Spearman-Karber method (Udupa, 1986) with the following formula:

$$\text{Log } m = xk + \frac{x}{2} - (\sum x\, pi)$$

With confidence interval is 95%, therefore

$$m \pm 1{,}96 \sqrt{x^2 \sum \left(\frac{pi - qi}{n_i - 1}\right)}$$

Where,
Log m = logarithm of fish length at the first mature gonad,
xk = mid-value logarithm at 100% mature gonad,
x = logarithm of length addition on mid-value,
pi = total of first mature gonad fish at length I class with total fish at interval i,
qi = 1- pi,
ni = total fish at length in class,
M = the length of the first mature gonad fish as antilog m.

Total fecundity was estimated with the gravimetric method (Effendie, 1979), sub-sample taken was as much as 0.01 gram from the total mass of the gonad. Total fecundity was calculated by using the following formula:

$$F = \frac{Q}{q} \times n$$

Where,
F = total fecundity (total eggs),
Q = the total weight of gonad (g),
q = the weight of sub-sample gonad (g),
n = total egg in gonad sub-sample (eggs).

RESULTS AND DISCUSSION

Size distribution

The size distribution of the fork length of Japanese Threadfin Bream obtained during the study for the male sex ranged from 15.0-27.3 cm (21.3±3.24 cm), and female ranged from 15.0-23.0 cm (19.2±2.54 cm) (Figure 2). Figure 2 shows that the male Japanese Threadfin Bream caught has an average size of length and a broader size distribution than the female fish. The dominant male fish was caught at 18-19 cm by 24.24%, while the dominant female Japanese Threadfin Bream was caught at 19-20 cm by 31.25%. The size distribution weight of males of Japanese Threadfin Bream ranged from 57.3-261.6 g (138.79±9.57 g), and females ranged from 60.1-223.3 g (119.5±7.79 g). The male Japanese Threadfin Bream has a more significant weight than the female with a distribution tendency, as shown in Figure 3. The dominant male fish caught at a size of 75-100 g is 27.27%, and the dominant female is caught at a size of 100-125 g at 34.38 %.

The results of Nettely *et al*. (2016) in the waters of Bintulu, Malaysia, showed that the size distribution of *Nemipterus japonicus* ranged from 19.0 to 29.9 cm. Wu *et al*. (2008) obtained the size distribution of *Nemipterus peroneii* in the southwest part of Taiwan waters ranging from 87.1-273.5 mm. Ozen (2021) found that the size distribution for *Nemipterus randali* ranged from 3.9-23.8 cm, with males being larger than females. Burcu & Sercan (2021) found the size distribution for *Nemipterus randali* fish to range from 9.2 to 21.2 cm.

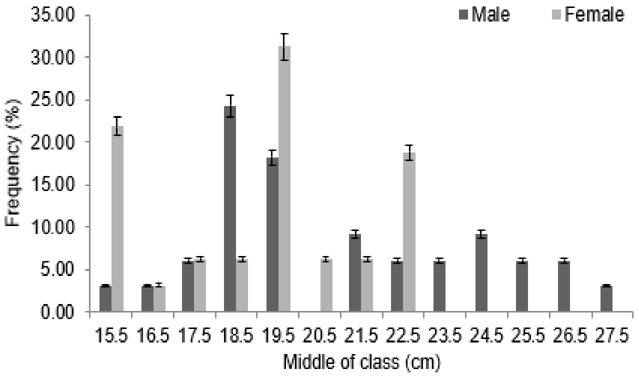

Figure 2. Fish length size distribution of *Nemipterus japonicus* male and female during the study.

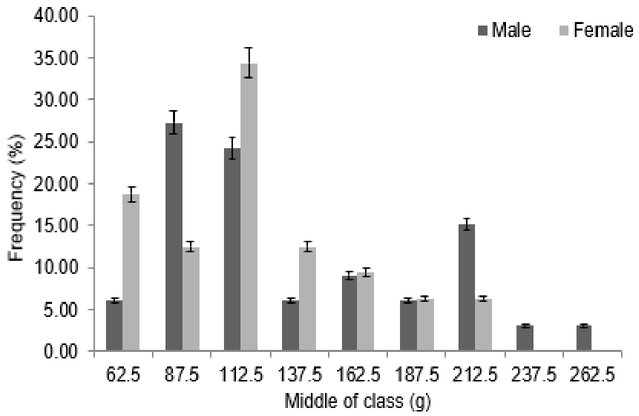

Figure 3. Fish weight size distribution of *Nemipterus japonicus* male and female during the study.

If the results of this study are compared with those reported, the size distribution tends to be similar. In the previously reported study, the dominant catch was in coastal waters, while in this study, it was caught on artificial reefs. This indicates that the fish caught on artificial reefs are thought to have come from other areas or locations to the artificial reefs to look for food and then settle if food availability is sufficient.

The distribution of the size of fish caught by sex in this study was predicted to be related to the size of the presence of fish on artificial reefs at the time of fishing and fish feeding time. Kantun *et al*. (2014) and Kantun *et al*. (2018) argue that the size distribution of fish caught by fishing gear can be influenced by fishing methods related to fishing time, feeding time, type of bait and depth position of fishing gear operation. Kasmi *et al*. (2017) revealed that the characteristics of the biological properties of fish with behaviour schooling to the same size and the same type so that when caught, they have similar sizes. In addition, the size distribution of fish caught is also strongly influenced by fishing gear.

Sex ratio

The number of Japanese Threadfin Bream caught in the vicinity of bioreeftek was 65, consisting of 33 male fish and 32 female fish, so the sex ratio obtained was 1: 1.03 (Figure 1). The sex ratios found in this study were balanced, indicating that the chance of new individuals occurring tends to be more significant. However, Figure 4 shows that the sex ratio of Japanese Threadfin Bream on artificial reefs is quite variable based on the time of observation. This variation in sex ratio is probably due to fish and fish feeding times that do not coincide, the biological nature of fish like schooling and reproductive behaviour that will soon enter the spawning season.

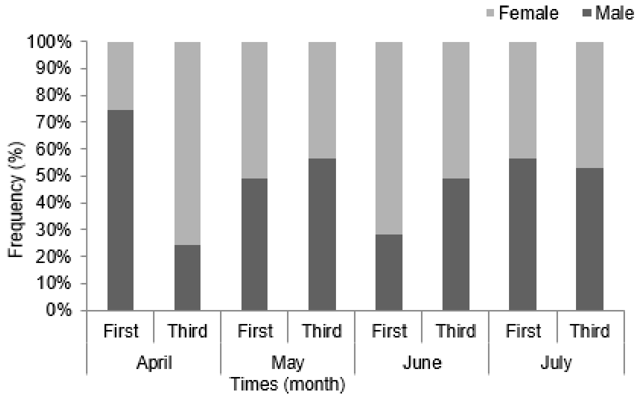

Figure 4. The sex ratio of *Nemipterus japonicus* caught on artificial reefs is based on sex and time of observation.

Persada *et al*. (2016) obtained a sex ratio of 1.1:1. Oktaviyani *et al*. (2016), in the waters of Banten Bay, found it was in a balanced state. Several factors are thought to cause variations in the sex ratio, including differences in reproductive behaviour, environmental conditions and the existence of fishing activities. Variations in the sex ratio can interfere with its sustainability. Persada *et al*. (2016) argue that if one fish sex is higher than the other in a population, it can disrupt the sustainability of the species by decreasing fish stocks in the waters so that, in the long term, it can cause the extinction of a fish population.

Gonad maturity stage (GMS)

During the study, samples of Japanese Threadfin Bream were obtained with gonad maturity level II to IV or not yet matured to gonad maturity (Figure 5). TKG II is included in the gonad immature category, and TKG III-IV is in the mature gonadal category. Male Japanese Threadfin Bream, which were in gonadally immature condition, were 12.12% and gonad mature was 87.88%, while female fish were gonadally immature by 21.87% and gonads matured 78.13%. The high gonad maturity obtained in this study was presumably because the Japanese Threadfin Bream were about to enter the spawning season. Other researchers, such as Persada *et al*. (2016), also found the gonad maturity of Japanese Threadfin Bream in immature to gonadal maturity (TKG I-III) for Japanese Threadfin Bream that landed at the Sungailiat Archipelago Fisheries Port. Sutjipto *et al*. (2013), in the waters of the Madura Strait, found Japanese Threadfin Bream fish spawn throughout the year and based on the peak of gonadal maturity occurring in February and November. Chullasom & Martusubroto (1986) found curried fish spawn in anuary and June-August.

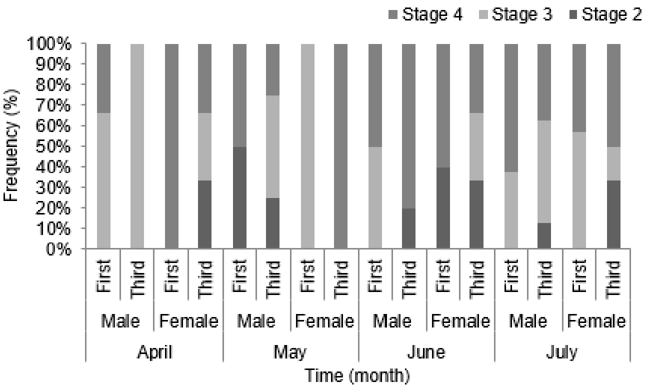

Figure 5. The frequency of the gonadal maturity stage of Japanese Threadfin Bream is based on sex and time of observation.

Figure 5 shows that each sampling found the gonads to be mature. This indicates that it had entered the spawning season when the research was conducted, although no spawning fish were found. Fish that will spawn may not be present on artificial reefs but seek a supportive environment for spawning, so they are not disturbed by other organisms.

Gonad maturity index (GIC)

The gonad maturity index values of Japanese Threadfin Bream obtained during the study based on sex ranged from 0.541-0.940 for males and 1.156-2.358 for females, as shown in Figure 6. Figure 6 shows an increase in the GIG value with increasing gonadal maturity of the fish. In addition, the average IKG value of female Japanese Threadfin Bream is greater than that of male Japanese Threadfin Bream at the same TKG and the average IKG value increases along with the increase in TKG with almost the same pattern of increase.

Brojo & Rian (2002) obtained a range value of IKG of female curd greater than that of male curd, with an average value of 0.95 for males and 2.00 for females. Netty et al. (2016) found that the IKG values of *Nemipterus japonicus* ranged from 0.07-0.19 for males and 0.34-4.99 for females. Persada *et al*. (2016) obtained IKG values ranging from 0.000057-0.00662 for males and 0.000542-0.02498 for females.

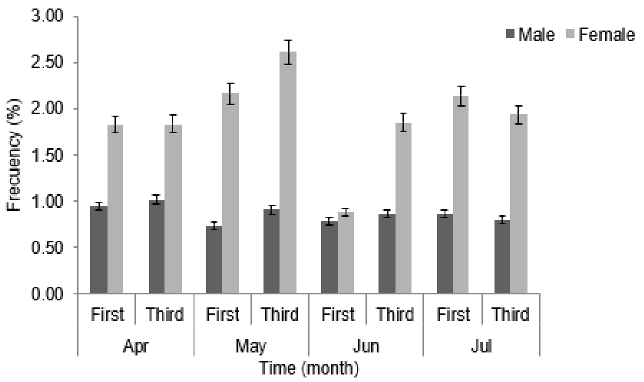

Figure 6. Gonad maturity index of Japanese Threadfin Bream caught in bioreeftech.

Syafei & Robiyani (2001) stated that the IKG value of females is generally higher than males because the growth of female fish tends to focus on gonadal development. The IKG value will be higher as the Gonad Maturity Stage value increases. This indicates that the weight of the gonads will reach a maximum when the fish spawn, then decrease rapidly during spawning until spawning is complete (Effendie, 1997). Effendie (1979) stated that the increase in gonad weight of female fish is more excellent and can reach 10-25% of body weight, while it is around 5-10% in male fish. It was further explained that, in general, the increase in gonad weight of female fish was caused by the increase in the weight of the ovaries, which was always more significant than the increase in the weight of the testes.

The size of the first maturity of the gonads

The size of the first gonadal maturity of Japanese Threadfin Bream fish obtained was 18.29 cm for males and 16.99 cm for females. While other researchers such as Brojo & Rian (2002) found a size of 17 cm, Oktaviyani *et al*. (2016) obtained size of 196 mm, Wahyuni *et al*. (2009) in Blanakan and Tegal obtained sizes ranging from 90-125, Manojkumar (2004) found at a size of 183 mm, Amine (2012) found a total length of 114 mm and 125 mm for males and females, respectively, and Sen *et al*. (2014) obtained a total length of 180 mm. Ozen (2020) obtained the first size of the gonads of *Nemipterus randali* for males at a size of 17 cm and 13 cm for females. Meanwhile, Rahman & Amira (2021) obtained the first gonad maturity size of *Nemipterus furcosus* at 15.8 cm for males and 15.6 cm for females. Burcu & Sercan (2021) found that the first gonad maturity of *Nemipterus randali* for females was 13.11 cm, and for males, 15.55 cm.

According to Effendie (2002), fish with the same species and scattered at latitudes with a difference of more than 5° have different sizes of first gonad maturity. Chullasorn & Martosubroto (1986) revealed that the growth rate of female Japanese Threadfin Bream fish is lower than that of male fish because the energy used for gonad growth is more significant than for body growth. The size of the first gonad maturity of each type of fish can vary within the same species (Udupa, 1986). This can be caused by differences in the food supply, water temperature and stock density (Tormosova, 1983). Another possibility is differences in fish adaptation patterns due to natural influences or fishing pressures.

Fecundity

The fecundity of Japanese Threadfin Bream was analyzed by utilizing the sample data in TKG III and TKG IV. The total fecundity obtained ranged from 35.042 to 42.061 eggs. Brojo & Rian (2002) obtained fecundity values ranging from 25.079 to 170. Eight hundred eighty-eight items with an average of 54.759 items. Wu et al. (2008) obtained the fecundity of *Nemipterus peroneii* fish ranging from 13.758 to 398.859 grains. Meanwhile. Persada et al. (2016) obtained the number of fecundities ranging from 39.728 to 40.921 eggs. Netty et al. (2016) found the fecundity of *Nemepterus japonicus* ranging from 19.221 to 85.923 grains. Rahman & Amira (2021) obtained the fecundity of *Nemipterus furcosus* in the range of 54.970 and 236.938 grains. The variation in the value of fecundity is thought to be caused by the uneven distribution of egg production, fertility, fishing intensity, egg size, water conditions, population density, and food availability.

Based on the amount of fecundity produced, the female Japanese Threadfin Bream in this study showed a high level of productivity. This refers to the opinion of Musick (2000), which reveals that the level of fish productivity is based on the reproductive index with fecundity parameters. The number of fecundities that is less than 10 items is classified as very low, 10-100 items are considered low, 100-1000 items are classified as moderate, and above 1000 items are classified as high. Furthermore, it is also stated that fecundity can be used as an indicator of the productivity of an organism which is supported by environmental factors, genetics, growth, age and gonad maturity.

CONCLUSIONS AND RECOMMENDATION

Conclusion

The sex ratio of Japanese Threadfin Bream caught in artificial reef "bioreeftek" is balanced. Fish dominated the fishes that were captured with matured gonads. The size of the first gonad mature for female Japanese Threadfin Bream is 16.99 cm, and for males, 18.29 cm, with a high reproduction potential ranging from 35.041-42.061 eggs.

Recommendation

The average size of Japanese Threadfin Bream caught was 21.3 cm for males and 19.2 cm for females, while the size of the first gonad maturity for male and female fish was 18.29 cm and 16.99 cm, respectively. This indicates that the average size caught is greater than the size of the first maturity of the gonads so that it is following the rules for maintaining the sustainability of the Japanese Threadfin Bream resources. That June and July are the peak stages of gonad maturity, so it is better to avoid catching on artificial reefs at that time.

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AUTHORS' CONTRIBUTIONS

The author works alongside collecting and processing data and compiling the concept of the article in activities that have been carried out in 2020.

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