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Evaluation of Reproductive Characteristics and Feed Utilization of Two Strains of *Heterobranchus bidorsalis* (Geoffrey, 1809)

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Authors' contributions

This work was carried out in collaboration between all the authors. Authors LUO and CD designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors SDD and KGM contributed in literature searches. All authors contributed and approved the final manuscript.

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ABSTRACT

Intraspecific hybridization studies were carried out in two strains of *Heterobranchus bidorsalis* obtained from two ecological zones in Nigeria – Yola (Sudan savannah) and New Bussa (Guinea savanna) with the aim of evaluating the fecundity, percentage fertilization, hatchability, growth rate and survival rate pure breeds and hybrids of both strains. The study was conducted in triplicates for a period of 56 days. *Heterobranchus bidorsalis* strains obtained from Yola had higher fecundity compared to the New Bussa broodstock. The average number of eggs in one gram obtained from female Yola broodstock (680) was significantly greater than those obtained (per gram) from the female New Bussa broodstock (647). The mean weight of female broodstock obtained from Yola was 7.8 kg while that from New Bussa was 2.5 kg, with a mean total length of 102 cm and 75 cm respectively and a total weight of 400 g and 160 g of stripped eggs. The pure breed (NN♀ x NN♂) and hybrid (NN♀ x YY♂) both had the highest percentage fertilization (30%). The highest percentage hatchability was recorded in the pure breed (YY♀ x YY♂) with 74.43%. In terms of weight (8.80 g) and length (7.22 cm), the pure breed (YY♀ x YY♂) had the best growth performance

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than the other crosses. YY♀ x NN♂ hybrid had the least growth rate in terms of weight (6.73 g) and length (4.70 cm). There were significant differences ($p<0.05$) between the specific growth rate (SGR) in the treatments with an average of 5.2%/day. The pure breed (NN♀ x NN♂) had the lowest survival rate (46.7%) and 80% was the highest percentage survival as recorded in the hybrid (NN♀ x YY♂).

Keywords: Intraspecific hybridization; Heterobranchus bidorsalis; fecundity; fertilization; hatchability; growth; survival.

1. INTRODUCTION

Aquaculture unlike capture fisheries requires deliberate human intervention in the organism productivity and yields that exceed those from the natural environment alone. Aquaculture genetics shows immense potential for enhancing production in a way that meets aquaculture development goals for the new millennium [1]. Aquaculture continues to grow more rapidly than all other animal food-producing sectors, with an average global annual growth rate of 8.8% per year since 1970, compared to only 1.2% for captured fisheries [2].

Fish is widely accepted because of its high palatability, low cholesterol and tender flesh [3]. High growth rate and disease resistance makes African catfish a regular species for homestead fish culture in different areas of the world [4]. African catfish is the major fish species cultured in Sub-Saharan Africa [5]. Catfishes of the family *Clariidae* comprise the most commonly cultivated fishes in Nigeria. The growth of aquaculture in Nigeria now is largely being boosted by a steady rise in catfish culture. Tremendous progress is now being made. The total value of the industry today is US$800 from the value of fingerlings, feed and farmed fish [6]. Among the culturable food fish in Nigeria, catfish is the most sought after fish species, very popular with fish farmers, consumers and commands a very good commercial value in Nigerian markets [7,8,9]. The catfish is very important to the sustainability of the aquaculture industry in the country.

Heterobranchus bidorsalis has received much attention and acceptability because of its economic importance and desirable attributes such as hardiness, high palatability, high fecundity, disease resistance and fast growth. Hence, it commands high commercial values [10]. A strain within a species is a population with common origin and history that possess a unique trait that distinguished it from other species. In this study, *Heterobranchus bidorsalis* strains obtained from two ecological zones were used in hybridization for evaluation. Hybridization is mating genetically of individuals or groups for improved performance. It may involve crosses within a species or crosses between separate species [11].

Several challenges have been recorded by researchers who have worked on *Heterobranchus bidorsalis*. [12], stated that there is limited availability of *Heterobranchus bidorsalis*. The dearth of African giant catfish *Heterobranchus bidorsalis* seeds pose great threat to its aquaculture and biodiversity [13]. Though the species has not been listed as endangered, there is risk of extinction because of environmental problems or effect of the breeding sites [14,15], hence the aim of the study was: to evaluate the growth performance of *Heterobranchus bidorsalis* strains from two ecological zones.

In order to further exploit the combination of important characteristics in different strains, there is a need to diversify research work on *Heterobranchus bidorsalis* from different ecological zones. Limited studies have been conducted on this species for improvement on its breeding [14,15] while few studies on hybridization and growth performance in comparison with other species are just developing [16,1,17,4,18].

Comparing the growth performance of *Heterobranchus bidorsalis* from the two ecological zones in this study will give added insight into improvement in the artificial propagation of this species and possible increase in production. The objectives of this study are to evaluate the fecundity of the female strains from two ecological zones, determine the percentage fertilization, and evaluate the hatchability of the different strains, the growth performance of *Heterobranchus bidorsalis* from two ecological zones and the survival of the different strains.

2. MATERIALS AND METHODS

2.1 Experimental Site

The study was carried out in the hatchery unit of Department of Fisheries, Modibbo Adama University of Technology, Yola, Adamawa State, Nigeria. The experimental site is located within the Guinea Savanna zone as described by [19].

2.2 Source of Broodstock

Two strains of *Heterobranchus bidorsalis* from two ecological zones of Nigeria New Bussa and Yola were used in the evaluation experiment under hatchery conditions. They were labeled as: YY for strains obtained from Yola and NN for strains obtained from New Bussa.

2.3 Experimental Set up, Feeding Rate and Frequency

Twelve (12) plastic bowls of 20 litres volume were used. Each treatment was in triplicate and fifteen (15) fingerlings stocked in each. The yolk-sacs of hatchlings were absorbed in 3-4 days after hatching and were fed with Artemia for the first seven days, and then with 0.2mm Coppens feed. Excess feed were siphoned every morning before feeding and the water increased to the preferred volume of 20 litres.

2.4 Artificial Fertilization and Incubation

The female broodstock were gravid with swollen abdomen that freely oozed out eggs upon gentle pressure on their abdomen from their pinkish or reddish swollen vents [20,21,12,22] and sexually matured male broodstock were identified and selected based on their external sexual characteristics. The matured males possessed prominent pinkish-coloured pointed genital papillae [14,22]. The method of fertilization carried out was done whereby eggs were fertilized with diluted sperm with physiological saline solution (0.9% NaCl) [23].

The synthetic hormone (Ovaprim) was used to inject the female fish of each strain at a single dose of 0.5 mg/kg of fish for a latency period of 12 hours. After ovulation, eggs were collected by pressing the abdomen manually in the direction of the caudal fin into a plastic bowl. The milt was obtained by surgical removal of the testes and diluted with 0.9% NaCl solution. To produce hybrids, the eggs from each strain were then fertilized by mixing them with the milt in a bowl and a feather was used to stir the mixture for even mixing. The number of eggs stripped was determined by subtracting the weight of female broodstock after stripping from its weight before stripping. Then the number of eggs in 1 gram of eggs was counted and the total number of eggs calculated by multiplying the number of eggs in 1 gram by the weight of stripped eggs. The fertilized eggs were placed on kakabans in each incubation tank. The experiment lasted for fifty six days.

2.5 Experimental Crosses

The following crosses were carried out in replicates:

1. NN♀ x NN♂ (pure breed)
2. YY♀ x YY♂ (pure breed)
3. YY♀ x NN♂ (hybrid)
4. NN♀ x YY♂ (hybrid)

Where:

YY is *Heterobranchus bidorsalis* strain from Yola
NN is *Heterobranchus bidorsalis* strain from New Bussa

2.6 Growth Parameters

The mean weight of fry in each bowl was determined weekly. After the 56 days period, the surviving fingerlings were counted and all fish from the tank were weighed in bulk. Final mean weight, weight gain (W_1 - W_0) and mean weight gained per day was recorded. Fry survival in each treatment was recorded daily.

Percentage fertilization and hatchability was determined for all the treatments. Percentage of fertilization in eggs was calculated according to [24] as follows:

$$\% \text{ Fertilization} = \frac{\text{No. of fertilized eggs}}{\text{No. of incubated eggs}} \times 100\%$$

Percentage hatchability was also calculated using the formula according to [24]:

$$\% \text{ Hatchability} = \frac{\text{No. of hatchlings}}{\text{No. of fertilized eggs}} \times 100\%$$

2.7 Measurement of Growth Parameters

Growth indices were estimated using the following formulae according to [24]:

Weight gain (g) = (Final weight−Initial weight) g

$$\text{Mean daily weight gain (g/day)} = \frac{W_1 - W_0}{T}$$

$$\text{Specific growth rate (\%/day)} = \frac{\ln W_1 - \ln W_0}{T} \times 100$$

Where:

W_1: Final mean body weight (g), W_0: Initial mean body weight (g)
T: Culture period in days

$$\text{Feed conversion ratio} = \frac{\text{Weight of dry feed fed (g)}}{\text{Live weight gain of fish (g)}}$$

$$\text{Survival rate (\%)} = \frac{\text{Final number of fry}}{\text{Initial number of fry}} \times 100$$

$$\text{Condition factor (K)} = \frac{100W}{L^3} \quad [25]$$

2.8 Water Quality Parameters

Water quality parameters such as pH, dissolved oxygen and temperature were monitored, while the optimum oxygen level was maintained. The water quality was regulated through proper monitoring and replacement thrice weekly.

2.9 Statistical Analysis

Data collected were analyzed with SPSS Statistics package (16.0) using analysis of variance (ANOVA) and means were analyzed using LSD.

3. RESULTS

3.1 Induced Breeding and Fecundity of the Female Strains of *Heterobranchus bidorsalis* from Two Ecological Zones

Table 1 shows the fecundity and number of eggs in relation to the weight of broodstock. The mean weight of female broodstock obtained from Yola was 7.8 kg with a mean total length of 102 cm had a total weight of 400 g of stripped eggs. The total number of eggs stripped was 272,000 (Table 1). On the other hand, the mean weight of female broodstock obtained from New Bussa was 2.5 kg and a mean total length of 75 cm had a total weight of 160 g of stripped eggs. The total number of eggs stripped was 103,520. There was significant difference ($p>0.05$) for length of female broodstock of both strains, weight of fish, weight of ovary, number of eggs, GSI (Gonadosomatic index) and relative fecundity of female broodstock of both strains of *Heterobranchus bidorsalis* from the two ecological zones.

The body weight of male broodstock used in the experiment in relation to the weight of their testes is shown in Table 2. Male broodstock from Yola had a mean weight of 1.5 kg and a testes weight of 5.12 g. New Bussa strains had a mean weight of 1.3 kg and testes weight of 5.43 g also. The weights of right and left lobes of the strains differ 2.52 g and 4.86 cm for Yola while New Bussa had 2.78 g and 4.88 cm respectively. The lengths of right and left lobes of Yola strain were 2.60 g and 4.92 cm while New Bussa had 2.65 g and 5.00 cm respectively. There were significant differences ($p<0.05$) in the weights and lengths of the lobes. Their average body lengths differed; 70 cm and 65 cm for Yola and New Bussa broodstock respectively.

3.2 Percentage Fertilization and Hatchability of Strains of *Heterobranchus bidorsalis* from the Two Ecological Zones

The pure breed (NN♀ x NN♂) and hybrid (NN♀ x YY♂) had the highest percentage fertilization (30%) while YY♀ x NN♂ was the lowest (21.7%) (Table 2). There was significant difference ($p>0.05$) between the percentage fertilization of crosses. The pure breed (YY♀ x YY♂) had the highest (74.43%) hatching rate while (NN♀ x YY♂) had the lowest value (49.03%). There were significant differences ($p>0.05$) between the percentage fertilization and hatchability of the crosses.

3.3 Growth Performance of Strains of *Heterobranchus bidorsalis* from Two Ecological Zones and Their Hybrids

Table 3 shows the initial weight, final weight, initial length, final length, mean weight gain, mean length gain, mean daily weight gain, the specific growth rate (SGR), condition factor and feed conversion ratio (FCR) of the experimental fishes.

YY♀ x YY♂ had the highest weight gain (8.80 ± 0.40g) and YY♀ x NN♂ had the least weight gain (6.73 ± 0.57g) was recorded with There were no significant differences ($p<0.05$) in initial weight of all treatments but there was significant

Table 1. Mean body weight, fecundity and testes of different strains of *H. bidorsalis*

Parameters	Yola strain	New Bussa strain	CV
Length of fish(cm)	102[a]	75[b]	21.57
Weight of fish(g)	7800[a]	2500[b]	72.77
Total weight of eggs(g)	400[a]	160[b]	60.61
Number of eggs/1g	680[a]	647[b]	3.52
Total Number of eggs	272,000[a]	103,520[b]	63.45
GSI	5.13[b]	6.40[a]	15.58
Number of eggs/unit Length(cm)	2666.67[a]	1380.27[b]	44.95
Number of eggs/unit Weight(g)	34.87[b]	41.41[a]	12.13
Body weight of male fish(g)	1500 [a]	1300 [a]	10.10
Length of male fish(cm)			
Weight of testes(g)	5.12 [b]	5.43 [a]	4.16
Weight of Right Lobe(g)	2.52 [b]	2.78 [a]	6.94
Weight of Left Lobe(g)	2.60 [b]	2.65[a]	1.35
Length of Right Lobe(cm)	4.86 [b]	4.88 [a]	0.29
Length of Left Lobe(cm)	4.92 [b]	5.00 [a]	1.14

Means with different superscripts are significantly different (p>0.05)
Key: CV=Coefficient of Variability; GSI=Gonadosomatic index

Table 2. Percentage fertilization and hatchability for intraspecific hybridization of strains of *Heterobranchus bidorsalis* from two ecological zones

	Treatments			
Parameters	**NN♀ x NN♂**	**YY♀ x YY♂**	**YY♀ x NN♂**	**NN♀ x YY♂**
% Fertilization	30 .00[a]	26.67[b]	21.67[c]	30.00[a]
% Hatchability	57.63 [a]	74.43[a]	53.33 [b]	49.03 [c]

Means with different superscripts are significantly different (p>0.05)

differences (p>0.05) between the mean weight gain between treatments. YY♀ x YY♂ also had the highest length gain (7.22 ± 0.81 cm). The least length gain (4.70 ± 0.51 g) was recorded in the YY♀ x NN♂. There were significant differences (p>0.05) between the mean length gain between treatments.

For specific growth rate (SGR), there were significant differences (p>0.05) between treatments while for feed conversion ratio (FCR), there were no significant differences (p<0.05) in the treatments. Fig. 1 shows the mean weekly growth pattern of *Heterobranchus bidorsalis* fingerlings. From the graph, it can be noted that YY♀ x NN♂ hybrid had the least growth rate in terms of weight (g) and length (cm).

The highest (80%) and lowest (46.7%) survival rates were recorded in NN♀ x YY♂ and NN♀ x NN♂ crosses respectively. This is shown in Table 4. In Table 5, the average percentage survival of *Heterobranchus bidorsalis* purebreds and hybrids fry for 28 and 56 days was observed. Apart from NN ♀ x YY♂ hybrid which had a constant survival rate of 80% within both periods, there were significant differences (p>0.05) between the survival rates at both 28 and 56 days in the other crosses. The weekly growth performance of the different strains and thie hybrids showed thst Yola strain had the best performance followed by the hybrid NN♀ x YY♂, New Bussa strain and least was the hybrid YY♀ x NN♂.

3.4 Water Quality Parameters

Table 5 shows the result of water quality parameters recorded during the period of the experiment. The pH, Dissolved Oxygen and Temperature throughout the period of the experiment ranged between 6.4-7.1(mol/L), 6.2-7.5 mg/litre and 20.5-23.0^{0}C respectively. There were no significant differences (p<0.05) in the pH and dissolved Oxygen between treatments but there was significant difference (p>0.05) in temperature.

4. DISCUSSION

From Table 1, it can be noted that *Heterobranchus bidorsalis* strains obtained from Yola had higher fecundity compared to the New Bussa broodstock. The relative fecundity, that is

the fecundity/total length or weight relationship showed an increase in number of eggs produced with increasing female size. The fecundity obtained this result were higher than what [26] obtained using the same species The average number of eggs in one gram obtained from female Yola broodstock (680) was significantly greater than those obtained (per gram) from the female New Bussa broodstock (647). This can be attributed to the difference in their weights and maturity of the broodstock. The mean weight of female broodstock obtained from Yola was 7.8kg while that from New Bussa was 2.5kg, with a mean total length of 102cm and 75cm respectively and a total weight of 400g and 160g of stripped eggs. There were significant differences ($p<0.05$) in the length of female broodstock, weight of fish, weight of ovary, number of eggs, GSI (Gonadosomatic index) and relative fecundity of female broodstock of both strains of *Heterobranchus bidorsalis*.

Table 3. Growth performance of *Heterobranchus bidorsalis* fingerlings

Parameters	NN♀ x NN♂	YY♀ x YY♂	YY♀ x NN♂	NN♀ x YY♂
Initial weight (g)	0.43± 0.00 [a]	0.40 ± 0.00 [a]	0.41± 0.01 [a]	0.44 ± 0.01 [a]
Final weight (g)	7.54 ± 0.00 [c]	9.20 ± 0.00 [a]	7.14 ± 0.16 [c]	7.75 ± 0.38 [b]
Initial length (cm)	0.53 ± 0.07 [c]	0.81 ± 0.00 [a]	0.51 ± 0.11 [c]	0.68 ± 0.12 [b]
Final length (cm)	5.83 ± 0.23 [b]	8.03 ± 0.00 [a]	5.21 ± 0.49 [c]	5.87± 0.63 [b]
Weight gain (g)	7.11 ± 0.43 [c]	8.80 ± 0.40 [a]	6.73 ± 0.57 [d]	7.31 ± 0.44 [b]
Length gain (cm)	5.30 ± 0.53 [b]	7.22 ± 0.81 [a]	4.70 ± 0.51 [d]	5.19 ± 0.68 [c]
MDWG (g/day)	0.13 [b]	0.16 [a]	0.12 [b]	0.13 [b]
SGR (%/day)	5.11 [b]	5.61 [a]	5.10 [b]	5.12 [b]
Condition factor (K)	3.81 [b]	1.78 [c]	5.05 [a]	3.83 [b]
FCR	0.053 [a]	0.052 [a]	0.053 [a]	0.053 [a]
SR (%)	46.7 ± 0.00 [d]	66.7± 0.00 [b]	53.3± 0.47 [ca]	80.0± 0.73

Means with different superscripts are significantly different (p>0.05)
Keys:
MDWG=Mean Daily Weight Gain
SGR=Specific Growth Rate
FCR=Feed Conversion Ratio
SR=Survival Rate
NN♀ x NN♂ = New Bussa x New Bussa strain (pure breed)
YY♀ x YY♂ = Yola x Yola strain (pure breed)
YY♀ x NN♂ = Yola x New Bussa strain (hybrid)
NN♀ x YY♂ = New Bussa x Yola strain (hybrid)

Table 4. Average percentage survival of *Heterobranchus bidorsalis* purebreeds and hybrids fry for 56 days under hatchery conditions

Genetic groups	Initial stocking	% survival after 28 days	% survival after 56 days	SEM
1. NN♀ x NN♂	15	60.0 [a]	46.7 [b]	2.58
2. YY♀ x YY♂	15	73.3 [a]	66.7 [b]	1.82
3. YY♀ x NN♂	15	55.6 [a]	53.3 [b]	1.07
4. NN♀ x YY♂	15	80.0 [a]	80.0 [a]	0

Means with different superscripts are significantly different (p>0.05)
Keys:
NN♀ x NN♂ = New Bussa x New Bussa strain (pure breed)
YY♀ x YY♂ = Yola x Yola strain (pure breed)
YY♀ x NN♂ = Yola x New Bussa strain (hybrid)
NN♀ x YY♂ = New Bussa x Yola strain (hybrid)
SEM = Standard Error of Mean

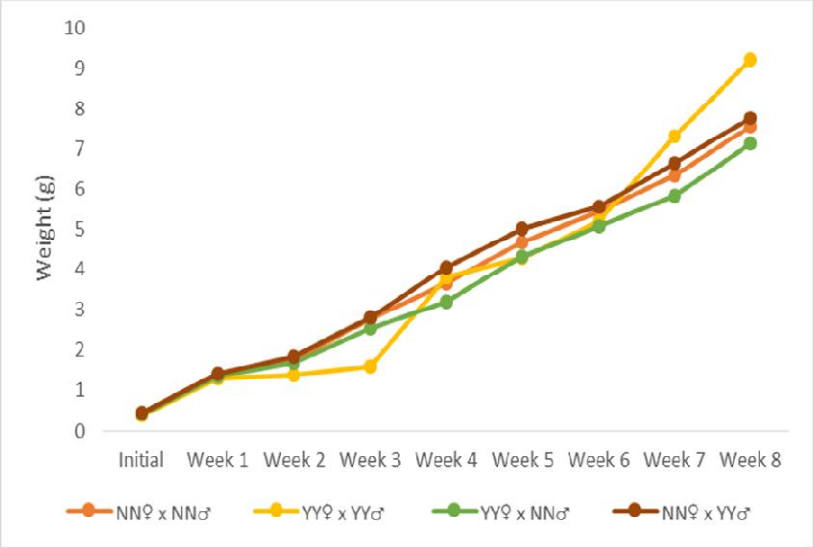

Fig. 1. Mean weekly growth pattern of *Heterobranchus bidorsalis* fingerlings

Table 5. Cumulative mean water quality parameters of experimental set up

Treatments	pH(mol/L)	Dissolved oxygen (mg/l)	Temperature (^{O}C)
1. NN♀ x NN♂	6.4 ± 0.6 ^{a}	6.2 ± 1.3 ^{a}	20.6 ± 2.4^{b}
2. YY♀ x YY♂	6.4 ± 0.7 ^{a}	6.2 ± 1.2 ^{a}	20.7 ± 2.3^{a}
3. YY♀ x NN♂	6.4 ± 0.5 ^{a}	6.2 ± 1.3 ^{a}	20.6 ± 2.4^{b}
4. NN♀ x YY♂	6.4 ± 0.6^{a}	6.2 ± 1.2^{a}	20.5 ± 2.5^{c}

Means with different superscripts are significantly different (p>0.05)

The results of this study revealed that the pure breed (NN♀ x NN♂) and hybrid (NN♀ x YY♂) both had the highest percentage fertilization (30%). However, 80.5% fertilization was obtained by [27]; 70% by [28 and 26]. This could be due to delay in fertilizing the eggs. The highest percentage hatchability was recorded in the pure breed (YY♀ x YY♂) with 74.43%. This might be attributed to egg quality and viability. This result was higher than what [26] had. However, [29] and [28] had higher percentage hatchability of 92.5% and 90%.

In terms of weight (8.80g) and length (7.22 cm), the pure breed (YY♀ x YY♂) had the best growth performance than the other crosses. YY♀ x NN♂ hybrid had the least growth rate (6.73 g) and (4.70 cm). This was as a result of mortality in the third to fifth week after stocking the fry. This redult however, was better that an average mean weight (5.04 g) obtained by [17]. The specific growth rate (SGR) in the treatments with an average of 5.2%/day was not in agreement with the findings of [1] 1.90 %/day and 0.66 %/day in [30]. There was no significant difference in the feed conversion ratio in all the crosses which showed the fish properly utilized the feed to grow.

The result of survival rate were in agreement with the results of [28 and 26] (76.67% and 53.28%).However, NN♀ x YY♂ had better percentage survival (80.0%) than the authors earlier mentioned. This differed from studies on *Heterobranchus bidorsalis* carried out by [1] where survival rate was 90% and 61.33% as recorded in [30]. The New Bussa strains reported by [31], had 57.4% survival rate while Ola-Oladimeji [27] recorded 56.50% survival rate in his study.

5. CONCLUSION

Generally, the pure breed (YY♀ x YY♂) did well by performing better than other crosses in terms of growth performance, fecundity and percentage hatchability. The hybrid (NN♀ x YY♂) had the highest percentage survival and the pure breed (NN♀ x NN♂) and hybrid (NN♀ x YY♂) both had the highest percentage fertilization. This implies that intraspecific hybridization of purebred *Heterobranchus bidorsalis* from Yola should be

explored for optimum performance. This will ensure high fecundity, hatchability and growth rate.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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