WILLY VILA NOVA PESSOA

FREQUÊNCIA ALIMENTAR E DESEMPENHO DE JUVENIS DO BEIJUPIRÁ, *Rachycentron canadum* (Linnaeus, 1766)

Recife, PE

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FREQUÊNCIA ALIMENTAR E DESEMPENHO DE JUVENIS DO BEIJUPIRÁ, *Rachycentron canadum* (Linnaeus, 1766)

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Dissertação apresentada ao Programa de Pós-Graduação em Recursos Pesqueiros e Aquicultura da Universidade Federal Rural de Pernambuco como exigência para obtenção do título de Mestre.

Prof. Dr. Ronaldo Olivera Cavalli
Orientador

Recife, PE

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RESUMO

O beijupirá (*Rachycentron canadum*) é uma espécie de rápido crescimento e alto valor de mercado e que recentemente tem despertado interesse no seu cultivo comercial no mundo, principalmente na Ásia. No Brasil, há relatos que a piscicultura marinha tenha se iniciado em Pernambuco no século XVII, quando algumas espécies eram cultivadas em viveiros estuarinos em Recife e Olinda. Atualmente, não há registros oficiais de produção da piscicultura marinha no Brasil. Apesar da piscicultura marinha não ser uma realidade como em outros países produtores no mundo, há boas condições para o desenvolvimento dessa atividade no Brasil. Algumas iniciativas têm sido tomadas para o cultivo do beijupirá tanto a nível comercial em mar aberto quanto a nível experimental nas universidades. Entretanto, como parte do processo de estabelecimento de uma indústria nova de cultivo há questões prioritárias que devem ser investigadas. Grande parte dos custos envolvidos no cultivo comercial de peixes é decorrente da alimentação, sendo imprescindível o seu melhor aproveitamento nos cultivos intensivos comerciais, bem como utilizar estratégias de alimentação que reduzam os custos principalmente para espécies carnívoras que exigem dietas com alto teor de proteína. No presente trabalho foram utilizados juvenis do beijupirá (*Rachycentron canadum*) com peso inicial de 110 g alimentados manualmente à saciedade. O presente estudo teve como objetivo avaliar efeito de diferentes frequências de alimentação (1, 2, 3, 4 e 6 refeições diárias) sobre o desempenho de juvenis do beijupirá durante 60 dias de cultivo em laboratório. Ao final do cultivo, os peixes foram contados, medidos, e a sobrevivência, peso final, ganho de peso, taxa de crescimento específico, taxa de conversão alimentar aparente, consumo alimentar aparente, fator de condição e coeficiente de variação foram estimados. Nessas condições experimentais, a frequência de alimentação não mostrou influência significativa no desempenho de juvenis de beijupirá entre 100 e 300 g. Entretanto, nos cultivos comerciais, onde há um maior número de animais cultivados, o comportamento do beijupirá, por ser mais agressivo, pode levar a lesões corporais devido a choque mecânico. Em vista disso, futuros estudos sobre o desempenho do beijupirá devem ser realizados em condições de campo.

Palavras-chave: Desempenho, estratégia de alimentação, frequência alimentar, beijupirá.

ABSTRACT

Cobia (*Rachycentron canadum*) is a fast growing and high value species that recently has drawn attention in the world, especially in Asia. In Brazil, there are reports that marine finfish culture started in Pernambuco, northeastern Brazil, in the 17th century, when several species were reared in estuarine ponds in the cities of Recife and Olinda. Currently, there is no official data on the production of marine finfish culture in Brazil. Although this activity is not a reality compared to other countries, it has good conditions for development in Brazil. A few initiatives of cobia culture have been undertaken both in offshore commercial operations as well as experimentally in universities. However, priority questions should be investigated as initial steps to begin this new industry in Brazil. Feeding is the major operational cost in commercial finfish culture operations and hence it is important to maximize performance as well as decrease feeding costs mainly to carnivorous fish such as cobia (*Rachycentron canadum*). This study assessed the growth performance under different feeding frequencies (1, 2, 3, 4 and 6 daily meals) under laboratory conditions for 60 days. Juveniles with mean initial weight of 110 g were hand-fed to apparent satiation the same daily amount. At the end of the trial, fish were counted, measured, and survival, final weight, weight gain, specific growth rate, feed intake, condition factor and coefficient of variation were estimated. The present results indicate that the number of daily feeding sessions had no significant effect on the growth performance of cobia juveniles reared under laboratory conditions weighting between 100 and 300 g. However, as under commercial rearing operations, when a larger number of animals are maintained, the aggressive behavior of cobia during feeding may lead to body injuries. Therefore, further investigations on the effects of feeding frequency are warranted, especially under field conditions.

Key words: Growth performance, feeding management, feeding frequency, cobia.

SUMÁRIO

1. INTRODUÇÃO

A produção da aquicultura mundial tem demonstrado um crescimento numa taxa anual de 8,3% entre 1970 e 2008. Durante esse mesmo período o consumo *per capita* de pescado cresceu de 0,7 kg para 7,8 kg, ou seja, um aumento de 6,6% por ano (FAO[1], 2010a). Em 2008, a aquicultura contribuiu com 46% do pescado destinado ao consumo humano no mundo, com 52,5 milhões de toneladas produzidas, das quais 19,7 milhões (37,5%) foram provenientes exclusivamente da maricultura (FAO, 2010a).

A piscicultura marinha é uma atividade comercial estabelecida mundialmente. No Brasil, a atividade não consta nas estatísticas para o Brasil (IBAMA[2], 2010). A piscicultura marinha brasileira detém conhecimento tecnológico para algumas espécies nativas de interesse comercial, embora grande parte das informações disponíveis necessitem de aprimoramento (ROUBACH et al., 2003). Durante vários anos foi avaliado o potencial de cultivo de algumas espécies nativas brasileiras como o robalo-peva (*Centropomus parallelus*) e o linguado (*Paralichtys orbignyanus*), mas somente por meio de investimentos recentes realizados para o beijupirá (*Rachycentron canadum*), é que empresas privadas passaram a demonstrar interesse de investimento nesta atividade (SAMPAIO et al., 2010).

O beijupirá é uma espécie que reúne excelentes condições para ser produzido no Brasil, especialmente na região nordeste, pois esta região apresenta uma condição de temperatura da água favorável ao cultivo marinho (LIMA, 2010), variando entre 25,3 e 29,5ºC durante o ano (MEDEIROS et al., 2009). O beijupirá, além de ser nativo da costa brasileira, apresenta uma elevada taxa de crescimento (4-6 kg por ano) e alto valor de mercado (SUN et al., 2006).

[1] *Food and Agriculture Organization of the United Nations*; excluído os dados de plantas aquáticas;
[2] Instituto Brasileiro de Meio Ambiente e Recursos Naturais Renováveis.

A produção mundial do beijupirá foi de 31,9 mil toneladas em 2009 (FAO, 2010b), sendo 98,7% desse total concentrados na Ásia, mais especificamente na China (produção estimada em 29,1 t) e em Taiwan (2,4 t). Além desses países, Belize (200 t), Martinica (25 t), Colômbia (5 t) e Cingapura (2 t) também são mencionados como produtores do beijupirá, segundo a FAO (2010b). Em Taiwan, o beijupirá é cultivado comercialmente em pequena e grande escala (LIAO et al., 2004). O Brasil não consta nas estatísticas da FAO, mas foram produzidas cerca de 40 toneladas do beijupirá através da iniciativa de uma empresa privada em Pernambuco em 2009 (CAVALLI et al., 2011). Esses dados indicam que o cultivo do beijupirá pode ser uma alternativa de investimento para outros países em desenvolvimento, principalmente para o Brasil, que detém condições ambientais favoráveis e área disponível para o cultivo tanto em mar aberto como em áreas abrigadas.

Recentemente, tem se dado grande importância ao cultivo do beijupirá. Entretanto, como parte do processo de desenvolvimento de tecnologia para uma espécie nova e de hábito alimentar estritamente carnívoro como o beijupirá, há exigências nutricionais e de manejo na alimentação imprescindíveis para o estabelecimento da sua viabilidade técnica e econômica. Segundo Sampaio et al. (2010) e Cavalli et al. (2011), as experiências com o cultivo do beijupirá no Brasil na região sudeste e nordeste ainda são limitadas, mas aparentemente convergem para a necessidade em produzir dietas de melhor qualidade nutricional visando o cultivo comercial.

No cultivo intensivo, a frequência alimentar, devido a sua relativa simplicidade de aplicação e impacto nos custos de alimentação, na mão de obra e saúde dos peixes, é a estratégia mais facilmente aplicada. As estratégias de alimentação interferem decisivamente no crescimento para diversas espécies, como para a truta arco-íris, *Oncorhynchus mykiss* (RUOHONEN et al., 1998), linguado, *Paralichthys olivaceus*

(LEE et al. 2000b), garoupa, *Epinephelus akaara* (JEONG et al., 2003), black sea trout, *Salmo trutta labrax* (BAŞÇINAR et al., 2007) e pargo australiano, *Pagrus auratus* (BOOTH et al., 2008).

De modo geral, a alimentação dos peixes é responsável por 40 a 70% dos custos operacionais (ANDERSON et al., 1997; RANA et al., 2009). Para o beijupirá, os custos operacionais com alimentação foram estimados em 46% nos cultivos de Taiwan (MIAO et al., 2009). No Brasil, segundo simulação de um cultivo por Sanches et al. (2008), o custo com alimentação do beijupirá pode variar entre 74% e 77%. De acordo com Cavalli e Hamilton (2009), o custo estimado da ração no cultivo do beijupirá pode representar até 80%, pois dependem de dietas com alto teor de proteínas.

A alimentação de peixes carnívoros remete a custos mais elevados, havendo a necessidade de ajustes na alimentação bem como das estratégias de manejo. Portanto, o presente estudo pretende avaliar o desempenho de juvenis de beijupirá frente à diferentes frequências de alimentação durante o cultivo intensivo.

2. REVISÃO DE LITERATURA

2.1. Histórico e situação atual da piscicultura marinha brasileira e mundial

Os primeiros relatos do cultivo de peixes marinhos são originários da Ásia, Egito e Europa central. Alguns documentos antigos indicam que as primeiras iniciativas de cultivo de peixes no mundo foram realizadas no Egito com a captura de tilápias com vara e linha e estocagem em viveiros por volta de 2.000 A.C. Somente em 475 A.C., porém, foram publicados por Fan Li, durante a dinastia de Zhou na China antiga, métodos de cultivo para a carpa (LIN, 1949). Este é considerado o primeiro documento escrito sobre a aquicultura no mundo e revela detalhes sobre o desenho e *layout* de viveiros, reprodução e técnicas de produção de alevinos da carpa comum (*Cyprinus* *carpio*) na China (BEVERIDGE e LITTLE, 2002). O nascimento da piscicultura marinha provavelmente somente ocorreu na Indonésia com o cultivo do milkfish (*Chanos chanos*) em 1400 D.C.

No Brasil, a piscicultura marinha provavelmente teve início em Pernambuco no governo de Maurício de Nassau no século XVII (CAVALLI E HAMILTON, 2007). Segundo relatos de Von Ihering (1932), havia uma produção extensiva em viveiros estuarinos nos municípios de Recife e Olinda na década de 1930. Os viveiros estuarinos dependiam exclusivamente da dinâmica das marés para renovação de água e, portanto, da entrada de espécies estuarinas, como carapebas, *Eugerres* sp. e *Diapterus* sp., tainhas, *Mugil* sp., camurins, *Centropomus* sp., e o mero, *Epinephelus* sp. Exemplares de camarupim, *Megalops atlanticus*, também eram encontrados nos viveiros, mas, por ser uma espécie de baixo valor comercial e piscívora, eram retirados dos viveiros de cultivo. Alguns anos mais tarde, Schubart (1936) relata de forma mais técnica que estes cultivos em Recife e Olinda contavam com 280 viveiros em 42,7 ha e produtividade entre 20 e 1500 kg/ha, apesar de serem realizadas despescas anuais somente em metade dos viveiros disponíveis.

Com o passar dos anos, a atividade da piscicultura marinha foi perdendo espaço e inexiste como atividade comercial nos dias atuais no Brasil. Consequentemente, a produção de peixes marinhos não possui registros nas estatísticas oficiais (IBAMA, 2007; FAO, 2010b). Segundo Roubach et al. (2003), a piscicultura marinha brasileira pode ser considerada restrita quase que exclusivamente às instituições de pesquisa, embora seja uma atividade comercial estabelecida em vários outros países no mundo.

Algumas instituições de pesquisa brasileiras já possuem conhecimento básico sobre a tecnologia de cultivo de diversas espécies marinhas. Merecem destaque espécies nativas, como o robalo-peva (*Centropomus parallelus*) e o linguado (*Paralichtys* *orbignyanus*) (BIANCHINI et al., 2005; CERQUEIRA, 2005). Também há estudos com o peixe-rei (*Odontesthes argentinensis*), robalo-flecha (*Centropomus undecimalis*), tainhas (*Mugil platanus* e *M. liza*), corvina (*Micropogonias furnieri*), pampo *(Trachinotus marginatus*), garoupa verdadeira (*Epinephelus marginatus*) e lutjanídeos (*Lutjanus analis* e *L. synagris*), e mais recentemente, com o beijupirá (*R. canadum*). Segundo Cavalli e Hamilton (2007), o beijupirá é a espécie que reuniria as melhores condições para a piscicultura marinha comercial, seguido dos robalos (*C. parallelus* e *C. undecimalis*), a garoupa (*E. marginatus*), linguado (*P. orbignianus*) e pargo-rosa (*P. pagrus*).

Além da enorme diversidade de espécies nativas marinhas, o Brasil possui uma extensão litorânea privilegiada (≈8.500 km), Zona Econômica Exclusiva (ZEE) de 4,5 milhões de km², as quais podem ser utilizadas na piscicultura marinha, além de um clima favorável ao cultivo. A região Nordeste, em especial, possui uma temperatura média variando entre 25,3 e 29,5ºC durante o ano (MEDEIROS et al., 2009). O litoral brasileiro possui condições favoráveis de temperatura superficiasl da água para o cultivo do beijupirá, notadamente para a faixa litorânea compreendida entre o Pará e norte da Bahia, mas com restrições sazonais no litoral do estado do Amapá, e nas regiões Sudeste e Sul (LIMA, 2010).

2.2. O beijupirá, *Rachycentron canadum* (Linnaeus, 1766)

Antigamente, o pescador que pescava o beijupirá içava uma bandeira no topo da vela da jangada, e ao chegar a terra, pagava patente aos demais jangadeiros, como se tivesse pescado o rei dos peixes (Nogueira, 1887). Assim, o beijupirá é um peixe historicamente apreciado no Brasil. Relatos da obra “Tratado Descritivo do Brasil em 1587” revelam algumas características peculiares do beijupirá:

> “Beijupirá é o mais estimado peixe do Brasil, tamanho e da feição do solho[3], e pardo na cor; tem a cabeça grande e gorda como toucinho, cujas escamas são grandes; quando este peixe é grande, é-o muito, e tem sabor saborosíssimo; a sua cabeça é quase maciça, cujos ossos são muito tenros, e desfazem-se na boca em manteiga todo; as fêmeas têm as ovas amarelas, e cada uma enche um prato grande, as quais são muito saborosas”.
>
> “Andam estes peixes pelos baixos ao longo da areia, aonde esperam bem que os arpoem; também morrem a linha, mas hão-lhes ir andando com a linha para comerem a isca, e assim a vão seguindo até que caem ao anzol, onde não bolem consigo; e porque há poucos índios que os saibam tomar, morrem poucos” (Sousa, 1987).

O beijupirá é muito apreciado para a pesca esportiva nos Estados Unidos, Austrália, Nigéria e Quênia. Entretanto, não há uma pescaria direcionada ao beijupirá, sendo sua captura incidental (SHAFFER and NAKAMURA, 1989). A produção do beijupirá proveniente da pesca no mundo não ultrapassa 10.133 mil t. Em 2009, os principais países produtores foram o Paquistão (2.581 t), Filipinas (2.014 t), Irã (1.196 t) e o Brasil (976 mil t) (FAO, 2010b). A captura incidental do beijupirá no Brasil é realizada principalmente por embarcações artesanais, correspondendo a 94% da produção total de 2006 (IBAMA, 2007).

O beijupirá é uma espécie pelágica e migratória que possui ampla distribuição geográfica, pois ocorre entre as latitudes de 32ºN e 28ºS, em todos os continentes, com exceção da porção leste do Oceano Pacífico (SHAFFER and NAKAMURA, 1989). Possui hábito natatório ativo e não possui vesícula gasosa, assim como os tubarões. É uma espécie nobre e conhecida vulgarmente como “cação de escama” entre os pescadores artesanais pernambucanos devido a sua semelhança com um tubarão de pequeno porte ou cação (Figura 1). O beijupirá possui um comportamento solitário no ambiente selvagem, pois não forma grandes cardumes (SHAFFER and NAKAMURA, 1989), pois possui baixa abundância (STANLEY and WILSON, 1997).

[3] Esturjão (*Acipenser sturio*): espécie marinha do qual se extrai o “caviar”.

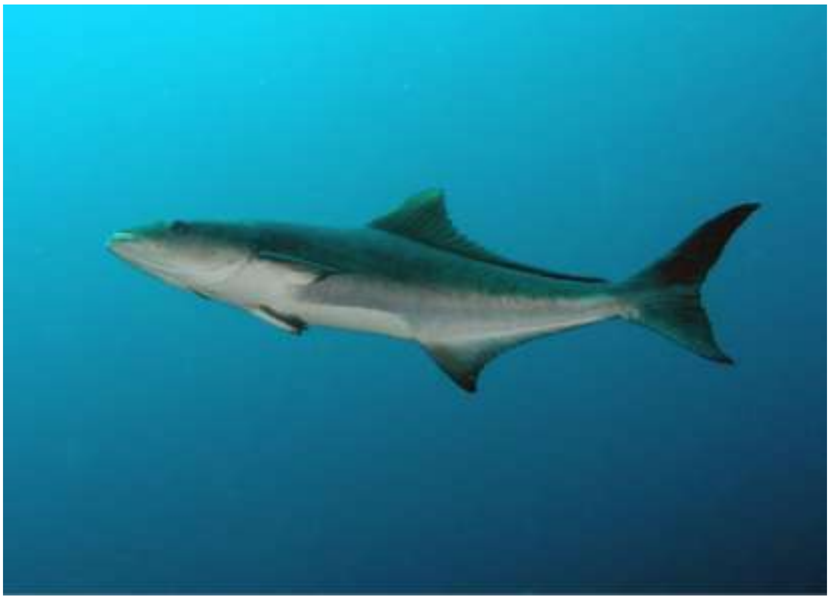

Fig. 1. Exemplar adulto do beijupirá, *Rachycentron canadum*, disponível em: http://www.fishbase.us/tools/uploadphoto/uploads/p6270042cobia.jpg.

O beijupirá possui hábito alimentar carnívoro basicamente composto por lulas e peixes demersais (SHAFFER and NAKAMURA, 1989), crustáceos e bivalves (ARENDT et al., 2001). Entretanto, o beijupirá possui um comportamento alimentar associado à disponibilidade de alimento do local onde vivem. Por exemplo, no litoral Pernambucano sua dieta é composta por peixes ósseos demersais com baixa capacidade de deslocamento (DOMINGUES et al., 2007). Um exemplar adulto do beijupirá pode atingir 68 kg e 2 m de comprimento (SHAFFER and NAKAMURA, 1989).

O beijupirá tem sido cultivado com sucesso desde a década de 90, principalmente na China e Taiwan (LIAO et al., 2004), mas outros países como Porto Rico e Vietnam já figuram na lista de produtores de beijupirá (BENETTI, et al., 2006; NHU et al., 2011). A primeira experiência de cultivo experimental do beijupirá data de 1975, nos Estados Unidos, quando ovos foram coletados e os exemplares mantidos em laboratório com sucesso por 131 dias (HASSLER and RAINVILLE, 1975). Relatos de cultivo foram relatados anos mais tarde nos Estados Unidos, Bahamas (BENETTI et al., 2006), Japão e Indonésia (LIAO and LEAÑO, 2007), Belize (SAMPAIO, 2006), Ilhas Reunião e Mayotte (GAUMET et al., 2007), México (SEGOVIA-VALLE et al., 2006), Tailândia, Irã, República Dominicana, Bahamas, Martinica e Panamá (BENETTI et al., 2008).

No Brasil, foram recentemente relatados o cultivo comercial e experimental do beijupirá nos estados de Pernambuco, São Paulo, Rio de Janeiro, Bahia, Espírito Santo Rio Grande do Norte e Paraná. De acordo com o Sistema de Informações das Autorizações de Uso de Águas de Domínio da União para fins de aquicultura - SINAU, em 2009, havia solicitações em andamento de projetos com a engorda do beijupirá para os estados da Bahia, Paraná, Rio de Janeiro e São Paulo (MPA, 2009).

Entre as características favoráveis dessa espécie, destacam-se o crescimento de 4 a 6kg/ano, crescimento compensatório quando cultivado em temperaturas mais baixas (18ºC), conversão alimentar entre 1,3 a 2,2 em sistemas de cultivo em mar aberto, adaptação ao confinamento, tolerância ao transporte em densidades de até 20 kg/m³, facilidade de desova em cativeiro, alto valor de mercado e excelente qualidade de carne (ARNOLD et al., 2002; BENETTI et al., 2010; CHOU et al., 2001; COLBURN et al., 2008; FAULK and HOLT, 2006; KAISER and HOLT, 2005; LIAO et al., 2004; SCHWARZ et al., 2007; SUN et al., 2006; WANG et al., 2005). Além disso, o beijupirá aceita com facilidade dietas extrusadas (CRAIG et al., 2006) e não apresenta dimorfismo sexual aparente para o crescimento até 400 g em cultivo intensivo (PESSOA et al., 2009).

O beijupirá não é uma exceção entre as espécies de hábito alimentar carnívoro, pois exige altos níveis de proteína na dieta. A concentração de proteína bruta (PB) que resulta em um desempenho zootécnico superior em juvenis de beijupirá foi estimada em

44,5% (CHOU et al., 2001), entretanto pode-se utilizar 40% de proteína bruta na dieta sem prejuízos produtivos (CRAIG et al., 2006) . As dietas comerciais para o beijupirá comumente usadas em Taiwan contém em média 48% de PB e 18% de lipídios totais, entretanto nos Estados Unidos as dietas comerciais são formuladas com proteína em excesso (58%) e 15% de lipídios (CRAIG et al., 2006). Em Taiwan, são utilizados níveis lipídicos em excesso para agregar valor ao beijupirá, o qual visa principalmente o mercado do *sashimi* (CRAIG et al., 2006). O beijupirá aceita ingredientes alternativos à farinha de pescado na sua dieta, tais como o farelo de soja (até 40%) e farinha de proteína de levedura (até 25%) sem prejuízos ao crescimento (ZHOU et al., 2005; LUNGER et al., 2006). Por outro lado, juvenis do beijupirá mostram uma baixa taxa de conversão alimentar quando alimentados com ingredientes de origem vegetal numa proporção acima de 48% na dieta (PESSOA, 2008).

Na Ásia, o beijupirá é cultivado com sucesso na região Sudeste de Taiwan em temperaturas que variam entre 23,5 e 28ºC com ciclo de cultivo de 11 a 14 meses (LIAO et al., 2004). Yu and Ueng (2007) relataram que o cultivo do beijupirá é realizado em temperaturas entre 15 e 30,5ºC em Taiwan, embora haja efeitos negativos no metabolismo e crescimento dos peixes. Nas Ilhas Penghu, na região central de Taiwan, a temperatura pode cair para 15ºC durante o inverno, resultando em crescimento mais lento, ciclo de cultivo acima de 17 meses e, em alguns casos, alta mortalidade (MIAO et al., 2009). É sabido que a temperatura que favorece o crescimento e a eficiência alimentar do beijupirá varia entre 27 e 29ºC (SUN et al., 2006); e acima de 28ºC acelera o metabolismo (YU and UENG, 2007). Além disso, o beijupirá possui crescimento compensatório mesmo quando mantido em temperaturas mais baixas (18ºC) (Schwarz et al., 2007). Portanto, no caso do Brasil, o melhor desempenho do beijupirá em temperaturas entre 27 e 29ºC pode restringir o seu cultivo em escala comercial à região nordeste do Brasil (CAVALLI e HAMILTON, 2009; LIMA, 2010).

Apesar das limitações ambientais enfrentadas em algumas regiões na Ásia, há uma indústria ativa e estabelecida. Algumas regiões do sudeste asiático possuem um inverno mais rigoroso, com fortes ventos e correntes os quais exigem gaiolas de cultivo mais reforçadas e de alta tecnologia para o cultivo (MIAO et al., 2009). Além disso, tufões são constantes e podem causar perdas na produção do beijupirá. Por exemplo, a produção do beijupirá aumentou de 1.800 t para 3.000 t entre 1999 e 2001, entretanto decresceu para 1.000 t em 2002 devido às perdas na produção decorrentes desses tufões e também de doenças em Taiwan (LIAO et al., 2004).

No Brasil, as condições para o cultivo comercial do beijupirá são tão boas, ou melhores, em comparação aos países produtores. No entanto, Cavalli e Hamilton (2009) e Cavalli et al. (2011) destacam que existem vários desafios para o desenvolvimento do cultivo do beijupirá no Brasil, tais como: mercado consumidor desconhecido para a espécie; inexperiência na atividade; falta de agilidade no andamento de solicitações de uso das águas de domínio da União[4], e inexistência de especialistas da área da piscicultura marinha, principalmente na área de patologia de organismos marinhos.

2.3. Alimentação e frequência de arraçoamento em piscicultura

A alimentação é responsável por mais de 50% dos custos de operação em cultivos intensivos (LOVELL, 2002). O custo da alimentação pode ser ainda maior em função do hábito alimentar da espécie e dos ingredientes utilizados na dieta. De forma geral, os peixes carnívoros, como o beijupirá, possuem alta exigência protéica. Além disso, o

[4]Instrução Normativa Interministerial Nº 06/04 que regulamentou o Decreto 4.895/03 para cessão de águas de domínio da União.

desperdício de ração com altos níveis de proteína pode impactar o meio ambiente através da liberação de compostos nitrogenados.

O papel da frequência de arraçoamento já vem sendo pesquisado há algum tempo (CHIU et al., 1987; GRAYTON et al., 1977; JOBLING, 1983; MURAI AND ANDREWS, 1976), e possui influência no crescimento (CHIU et al., 1987; LEE et al., 2000b; SILVA et al., 2007), consumo de ração (WANG et al., 1998), composição corporal (LEE et al., 2000a), utilização do alimento (RUOHONEN et al., 1998), taxa de conversão alimentar (BAŞÇINAR et al., 2007), e variação no tamanho dos peixes (ZAKĘŚ et al., 2006). Além disso, possui efeito sobre o tempo de evacuação do alimento (BOOTH et al., 2008) e no consumo de oxigênio (GUINEA and FERNANDEZ, 1997). A frequência de alimentação também tem relação direta com a viabilidade econômica (BAŞÇINAR et al., 2007), pois pode diminuir consideravelmente os custos de produção (CHIU et al., 1987). A taxa de alimentação, frequência alimentar e o tamanho das partículas da dieta interferem no crescimento, conversão alimentar, uniformidade do tamanho dos peixes, custo de produção e na quantidade de alimento desperdiçado (LOVELL, 2002).

A frequência alimentar pode aumentar a capacidade de assimilação do alimento (CHIU et al., 1987), além de ser uma estratégia relativamente simples de ser aplicada nos cultivos. A frequência alimentar também está relacionada com o tamanho do peixe, teor de proteína e níveis de energia na dieta (LEE et al., 2000b). No cultivo do salmão, o fornecimento de ração durante a fase juvenil é quase que constante, mas durante a engorda geralmente são alimentados de uma a duas vezes ao dia (LOVELL, 2002).

Geralmente, em peixes de hábito alimentar omnívoro, herbívoro ou frugívoro a alimentação deve ser dividida em mais vezes durante o dia. Por exemplo, para uma espécie frugívora, como o tambaqui (*Colossoma macropomum*), três refeições diárias proporcionam maior taxa de crescimento de juvenis (peso médio de 2,6 g) quando comparado a duas refeições (SILVA et al., 2007). Juvenis de tilápia do Nilo (*Oreochromis niloticus*) com 183 g apresentam crescimento e eficiência alimentar superiores quando alimentados duas, três ou cinco vezes ao dia comparado a uma alimentação diária (RICHE et al., 2004). Para o herbívoro “milkfish” (*C. chanos*), oito refeições diárias proporcionaram um crescimento e eficiência alimentar superiores (CHIU et al., 1987).

Apesar dos trabalhos publicados sobre os diversos temas que envolvem a piscicultura intensiva para peixes, há pouca informação disponível a cerca da frequência de alimentação para o beijupirá, principalmente para o juvenil. Durante o período de transferência do alimento vivo para a microdieta (“desmame” ou “*weaning*”), as larvas de beijupirá são alimentadas cinco (NHU, 2009) ou seis vezes ao dia (LIAO et al., 2004). Larvas com 20 DAE (dias após eclosão) podem ser alimentadas dez vezes ao dia (NGUYEN et al., 2011). Tanto para juvenis (3 g) quanto para larvas (15 mm), o aumento da freqüência não interferiu no desempenho zootécnico (NHU, 2009; ROMBENSO et al., 2009). Nos cultivos comerciais do beijupirá em Taiwan são utilizadas uma (LIAO et al., 2004) ou duas alimentações durante a fase de engorda (PAN, 2005). No Brasil, são utilizadas uma ou duas alimentação diárias em cultivo comercial em mar aberto (CAVALLI, 2011)[5]. Em viveiros escavados, beijupirás com peso inicial 70 g são alimentados duas vezes ao dia à saciedade aparente até atingirem 2,8 kg em 12 meses de cultivo (ANDRADE, 2011)[6]. A mesma frequência de alimentação foi utilizada no cultivo em viveiros na Bahia (CARVALHO FILHO, 2010).

[5] R.O Cavalli. ”Comunicação pessoal”, 11 de janeiro de 2011, Ronaldo Olivera Cavalli (orientador), UFRPE, Pernambuco, PE, Brasil.
[6] A. Francisco. “Comunicação pessoal”, 1 de junho de 2011. Francisco Andrade (Engenheiro de pesca), Empresa Atlantis, Pernambuco, PE, Brasil.

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4. ARTIGO CIENTÍFICO

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Does feeding frequency affect the growth performance of cobia (*Rachycentron canadum*) juveniles?

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Abstract

Aquaculture production of cobia is gradually increasing due to its rapid growth and market value. Since feeding is the major operational expense in cobia farming, rational use must be exercised. Proper feed management affects not only productive parameters, such as growth and feed conversion, but may also have an effect on environmental quality. This study assessed the role of feeding frequency on growth, survival, feed intake and size heterogeneity of cobia under laboratory conditions. Juveniles (mean weight of 110 g) were hand-fed a commercial diet containing 45% crude protein and 10% total lipids for 60 days. The same amount of feed was offered in 1, 2, 3, 4 or 6 daily meals during light hours. Groups of 8 fish were randomly distributed in twenty 500 L tanks that were continuously supplied with filtered seawater at a rate of 5 L min^{-1}. Survival, weight gain, specific growth rate, feed intake, condition factor and size variation were not significantly affected by the number of daily meals. Our results indicate that the number of daily feeding sessions has no significant effect on the growth performance of cobia juveniles under laboratory conditions. However, as in commercial farming operations a large number of fish is reared within a single structure, the behavior of cobia during feeding may lead to aggressive interactions. Under these conditions, it is difficult to ensure that all the fish are fed to satiation and thus it is usual to provide two meals per day. Therefore, although our results indicate that for an individual cobia the provision of more than one daily meal has no effect on growth performance, further investigations on the effects of feeding frequency are warranted, especially under field conditions.

Keywords: Growth, feed management, feeding, cobia.

1. Introduction

Cobia (*Rachycentron canadum*) is a marine finfish species with emerging potential for aquaculture. This species presents several characteristics that turn it into a natural candidate for mariculture: easiness of spawning in captivity and high fecundity (Franks et al., 2001; Arnold et al., 2002), established larviculture protocols (Holt et al., 2007), capacity for rapid growth rates (Chou et al., 2001), amenability to a variety of rearing techniques and culture systems, adaptability to commercially available aquafeeds and a high quality white flesh (Liao et al., 2004; Liao and Leaño, 2007). As a result, production of cobia in the past decade has increased significantly in tropical and subtropical areas of the world. In 2009, a total of 31,926 Mt of cobia were harvested from aquaculture farms (FAO, 2011). Main producing countries are China, Taiwan and Vietnam (FAO, 2011; Nhu et al., 2011), but attempts to rear cobia have also been reported in the USA, La Réunion Island, Japan, Indonesia (Liao and Leaño, 2007), United Arab Emirates (Yousif et al., 2009), Belize, Panama, Brazil, Mexico, Dominican Republic, Martinique, Puerto Rico, Thailand, Iran, Dominican Republic, Bahamas, Martinique (Benetti et al., 2010), Colombia, Singapore, (FAO, 2011) and India (Gopakumar et al., 2011).

Feeding is considered the most expensive operational cost in cobia farming (Sanches et al., 2008; Miao et al., 2009). So far, however, little work has been carried out to establish proper feed management practices, despite its potential to reduce both economical and environmental pressure in marine fish culture operations. For instance, it is well established that feeding frequency plays a crucial role on fish performance (Elliott, 1975; Murai and Andrews, 1976; Jobling, 1983; Tung and Shiau, 1991; Thomassen and Fjaera, 1996; Johansen and Jobling, 1998; Wang et al., 1998; Liu and Liao 1999; Sanches and Hayashi, 2001; Schnaittacher et al., 2005) and ultimately on the economic viability of fish farms (Başçinar et al., 2007), yet this aspect has not been properly considered for cobia (Chen and Liao, 2007; Fraser and Davies, 2009).

Feed management is known to affect not only productive parameters, but it also influences environmental quality (Lovell, 2002). Although there is a trend towards the establishment of open ocean farms, at present most cobia farming operations are carried out in floating cages placed in protected areas. Under these conditions, net pen marine aquaculture operations directly release waste and uneaten food into the environment, which may impact water quality and change the chemical and biological structure of the sediment. Alongi et al. (2003) and Tacon and Forster (2003) agree that environmental impact may occur if feeding regimes are inappropriately employed.

Based on work with other marine finfish species, it is hypothesized that feeding frequency will affect the growth performance of cobia. The present study was therefore designed to determine the number of daily feeding sessions that results in maximum growth of juvenile cobia under laboratory conditions.

2. Material and Methods

Cobia juveniles weighing around 100 g were obtained from a private hatchery (Aqualider Maricultura S.A., Ipojuca, PE, Brazil). Ten fish were stocked into each of twenty 500 L flow-through circular tanks. Tanks were supplied with a continuous flow (approximately 5 L/min) of sand-filtered seawater and continuous aeration. Water temperature, salinity and dissolved oxygen were monitored in each tank daily using a multi-parameter (YSI 556 - Yellow Springs Instruments, USA), while concentrations of total ammonia and nitrite were determined every three days with commercial kits (Labcon tests – Alcon, Brazil).

Before initiation of the experiment, the fish were conditioned for one week and fed twice daily (at 0700 h and 1700 h) to apparent satiation a commercial diet containing 45% crude protein and 10% lipids (Socil Evialis, São Lourenço da Mata, PE, Brazil). After conditioning, all fish were pooled and those of similar size were visually selected, weighed and measured. Mean (± SE) initial weight and total length were 109.7 g (± 0.9) and 24.84 cm (± 0.03), respectively. Eight fish were then randomly restocked in each tank in five treatments (one, two, three, four or six daily meals) and four replicates. Photoperiod regime was natural (08° S) and the diurnal cycle lasted from sunrise at 0530 h and sunset at 1730 h over the course of the experiment. First and last meals were offered at 0700 h and 1700 h, respectively.

The experiment lasted 60 days during which period the fish were hand-fed the same commercial diet as in the conditioning period. Feed was offered the same daily amount (3% of fish biomass per day) for all treatments (Liao et al., 2004). Feed consumption was monitored and recorded at each feeding. Dead fish, if any, were removed daily from the tanks and weighed. Tanks were scrubbed and siphoned every other week while fish were removed and weighed. Tanks were covered to reduce both fish losses from jumping and the incidence of direct light.

Every 15 days, four fish from each tank were anesthetized with 5 ppm clove oil (AQUI-S, Bayer S.A., Chile) and weighed individually. At the end of the feeding period, all fish were counted and weighed. Survival, weight gain (WG), feed conversion ratio (FCR), specific growth rate (SGR), condition factor (K) and apparent feed intake (FI) were determined. The following formulae were used to assess these parameters:

WG (%) = (final weight – initial weight) x (initial weight)/100

FCR = (dry feed fed) /(wet weight gain)

SGR (%/day) = [ln (final weight) x ln (initial weight)]/(number of days) x 100

K = [(weight)/(length)^3] x 1000

FI (% body weight/day) = 100 x [average individual feed intake x (initial weight/final weight)$^{0.5}$)]/number of days

The coefficient of variation (CV) was determined to evaluate the inter-individual weight variation among the fish biomass in each tank. Also, the variation of CV (VCV) was determined to indicate the percentage relative change of CV between initial and final fish weight (Wang et al., 1998). CV was calculated as CV (%) = (SD/mean weight) x 100, while VCV (%) = [(CV_f - CV_i)/(CV_i)] x 100.

All data are reported as mean ± standard error (SE). Analysis of variance (ANOVA) was applied to determine statistical differences between treatments. Analysis of the data was based on normality assumptions of ANOVA. Tukey's multiple range test was used to examine differences between treatments whenever significant differences were detected by ANOVA at a probability level of 5%.

3. Results

Mean (± SE) temperature, dissolved oxygen and salinity levels were 28.2ºC (± 0.01), 6.71 mg L^{-1} (± 0.04) and 38.7 (±0.04), respectively. Mean (± SE) total ammonia-nitrogen was 0.28 mg/L (± 0.02), while no nitrite was detected. Water quality variables throughout this study were therefore considered within ranges suitable for cobia development.

One replicate of the treatment with three daily meals was lost due to the lack of water flow overnight. Parameters of growth performance are summarized in Table 1, while the variation of the mean weight of cobia juveniles during 60 days is depicted in Figure 1. Survival ranged from 93.3 to 100% and no significant differences between treatments were observed (P>0.05). Initial and final weights, WG and SGR were not significantly different between treatments (P>0.05). The condition factor (K) ranged from 6.9 to 7.4 at the beginning of the trial, but it increased significantly to 8.0-8.4 after 60 days (P<0.05). Again, however, no differences were observed between treatments (P>0.05). FCR and apparent feed intake were also not significantly different between treatments (P>0.05). The coefficient of variation (CV) and the variation of CV (VCV) presented neither significant differences between treatments nor changes over time (P>0.05).

4. Discussion

Our results are contrary to the hypothesis that cobia juveniles would grow faster if they were fed a commercial diet more frequently. We found that cobia from all treatments grew at the same rate. None of the parameters associated with growth performance (survival, final weight, WG, SGR, FCR and K) showed any significant differences between treatments. Earlier work with other species of finfish indicates a relationship between gastro-intestinal evacuation rate and the establishment of optimal feeding frequency regimen (Elliot, 1975; Gwither and Grove, 1981; Grove et al., 1985). Although no work has as yet defined this aspect in cobia, Zhou et al. (2004) assessed the digestibility of selected feed ingredients and collected feces 16 h after feeding. In a similar study, juveniles that were not fed for 24 h were observed to start defecating 8 h after feeding was resumed (Costa-Bomfim et al., in preparation). Based on these results, it is reasonable to assume that one or two daily feeding sessions would be indicated for cobia juveniles.

To our knowledge, there is only one study available on the effect of feeding frequency on cobia juveniles. Rombenso et al. (2009) reported similar survival and growth when cobia with an initial size of 3 g were reared in 1 m^3 cages and fed 3, 6 or 9 daily meals. However, they did not investigate the effects of feeding cobia less frequently than three times per day so the effect of feeding cobia juveniles once or twice daily under field conditions remains to be examined. In a study with larval cobia, Nhu (2009) found no significant differences in growth when a weaning diet was offered continuously (from 0600 h till 1800 h) or divided into 4 or 7 daily meals for 15 days. This author found, however, that mortality due to cannibalism was lower in the continuous feeding regime, but there were no differences between 4 or 7 meals per day. Cannibalism is promoted by differences in fish size and, among other factors, it may be affected by feed availability (Goldan et al., 1997; Wang et al., 1998). In other finfish species, increasing feeding frequency has been demonstrated to control size variation and thus reduce mortality due to cannibalism as well as the stress and labor costs related to grading (Dou et al., 2000; Goldan et al., 1997; Wang et al., 1998). In this study, however, size variation was not significantly affected by feeding frequency and no significant differences in survival were observed.

The condition factor (K) increased from the beginning to the end of this study. The significant increase in K indicates that fish probably received enough food during the experimental period (Thomassen and Fjaera, 1996). Chuang et al. (2010) found that the condition factor of 6-7 kg cultured cobia ranged from 12.3 to 13.3, which was significantly higher than those of wild cobia (9.6) from Taiwanese waters. Lipid levels were also higher in the flesh of cultured cobia. In this regard, Benetti et al. (2010) reported that cultured cobia usually present excessive intra-peritoneal fat and abnormally large livers, and their bodies are shorter and fatter than wild-caught fish. These morphological patterns may be related to an increased feed intake and lower swimming and feed activities of cultured fish in comparison to their wild counterparts (Christiansen and Jobling, 1990; Boisclair and Tang, 1993).

The effects of feeding frequency on fish growth is also related to the size of the stomach, since species with smaller stomachs require more frequent feeding to achieve maximum growth (Pillay and Kutty, 2005). In nature, cobias are known to be voracious feeders, often ingesting whole preys (Shaffer and Nakamura, 1989). Carnivorous fish such as cobia are morphologically capable of ingesting large preys as they distend their stomachs to increase storage capacity. This allows them to be satiated after a single, large meal. On the other hand, omnivorous and herbivorous fish have comparatively smaller stomachs, but longer intestines. It is therefore commonplace that higher weight gains are observed when several daily meals are offered, as has been observed for tilapia (Tung and Shiau et al., 1991; Sanches and Hayashi, 2001; Riche et al., 2004).

The present results suggest that there is no benefit in feeding cobia larger than 110 g more than once daily. However, in practical farming operations, cobias may be fed more than once per day. During weaning, cobia are fed manually to satiation 5 to 6 times daily (Liao et al., 2004) or as many as 10 times a day (Nguyen et al., 2011). In grow-out carried out in sea cages, cobia may be fed once a day and 6 days a week (Liao et al., 2004) or twice a day (Benetti et al., 2010), while in recirculation aquaculture systems dividing feeding in several daily sessions is preferred as a way to avoid peaks of oxygen demand and ammonia excretion by fish. The discrepancy between the present results and the current practices in some cobia farms may be explained by differences in fish size and rearing systems. In commercial cobia farming operations, a large number of fish are maintained within a single rearing structure and it is quite common that the behavior of cobia during the feeding period may lead to aggressive interactions. Under these conditions, it is also difficult to ensure that all the fish are fed to satiation. It is therefore common to use a fixed ration, and offer two meals per day. This would provide a better opportunity for smaller, less aggressive fish to obtain food (Schnaittacher et al., 2005) and consequently fish of more uniform sizes are produced (Wang et al., 1998). Unfortunately, little is known about size hierarchy and social dominance among cobia under practical farming conditions. Work with the gilthead sea bream (*Sparus auratus*) has shown that a linear dominance hierarchy is established in groups of less than 10 fish (Goldan et al., 2003; Montero et al., 2009), and that aggressive interactions occur during feeding (Karplus et al., 2000; Goldan et al., 2003). Montero et al. (2009) found that this type of aggressive interaction is more pronounced when the number of individuals in the group is small, with a linear hierarchy more easily established in groups of five animals compared to groups of 10 animals. *S. aurata*, however, is a schooling fish, which contrasts to cobia, a species that is usually solitary or found in groups of 2-8 individuals (Shaffer and Nakamura, 1989).

Another possible explanation for the lack of significance in cobia growth when an increased number of daily meals is offered may be due to the food passing too rapidly through the digestive tract when the interval between meals is short. This would decrease the effectiveness of the digestion and assimilation processes (Liu and Liao, 1999). Furthermore, repeated feeding throughout long periods of the day may increase swimming activity of the fish and hence lead to higher energy expenditure and negatively affect growth rates (Johansen and Jobling, 1998).

The present results suggest that there is no benefit in feeding cobia juveniles larger than 110 g more frequently than once daily. Therefore, it may be possible to reduce feeding frequency in cobia farms without adversely affecting survival, growth rate and size variation, thereby improving profitability through decreased labor costs as well as facilitating offshore grow-out operations. This possibility, however, warrants further testing under practical, field conditions.

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Table 1. Mean (± SE) performance parameters of cobia (*Rachycentron canadum*) juveniles fed a commercial diet under different feeding frequencies for 60 days.

	Number of daily meals				
	One	Two	Three	Four	Six
Survival (%)	97.5 (± 2.5)	100.0 (± 0.0)	93.3 (± 3.3)	95.0 (± 2.9)	97.5 (± 2.5)
Initial weight (g)	112.48 (± 1.95)	110.96 (± 0.72)	109.13 (± 2.98)	108.43 (± 1.81)	107.08 (± 0.66)
Final weight (g)	273.97 (± 10.11)	303.10 (± 5.85)	292.25 (± 8.89)	277.62 (± 10.45)	271.40 (± 6.35)
Weight gain (%)	143.51 (± 7.36)	173.16 (± 4.86)	168.18 (± 10.78)	156.04 (± 8.59)	153.46 (± 5.56)
SGR (% day^{-1})	1.48 (± 0.05)	1.67 (± 0.03)	1.64 (± 0.07)	1.56 (± 0.06)	1.55 (± 0.04)
Initial K	7.4^{A} (± 0.1)	7.1^{A} (± 0.2)	7.2^{A} (± 0.1)	7.2^{A} (± 0.1)	6.9^{A} (± 0.1)
Final K	8.2^{B} (± 0.2)	8.4^{B} (± 0.1)	8.0^{B} (± 0.3)	8.2^{B} (± 0.1)	8.1^{B} (± 0.0)
FCR (g fed g gained^{-1})	1.77 (± 0.01)	1.55 (± 0.05)	1.63 (± 0.09)	1.75 (± 0.12)	1.79 (± 0.11)
Apparent feed intake (% body weight day^{-1})	2.69 (± 0.07)	2.69 (± 0.03)	2.77 (± 0.04)	2.82 (± 0.13)	2.87 (± 0.10)
Initial CV (%)	12.0 (± 1.6)	7.2 (± 0.9)	7.3 (± 0.4)	9.1 (± 2.3)	13.0 (± 2.6)
Final CV (%)	15.2 (± 2.5)	13.6 (± 1.4)	15.5 (± 3.0)	15.4 (± 3.4)	21.3 (± 3.8)
Variation of CV (%)	38.0 (± 35.2)	101.9 (± 36.6)	108.9 (± 30.1)	73.9 (± 18.8)	84.7 (± 53.8)

No significant differences were found between treatments for any of the parameters ($p>0.05$). Capital superscript letters indicate significant differences over time ($p<0.05$).

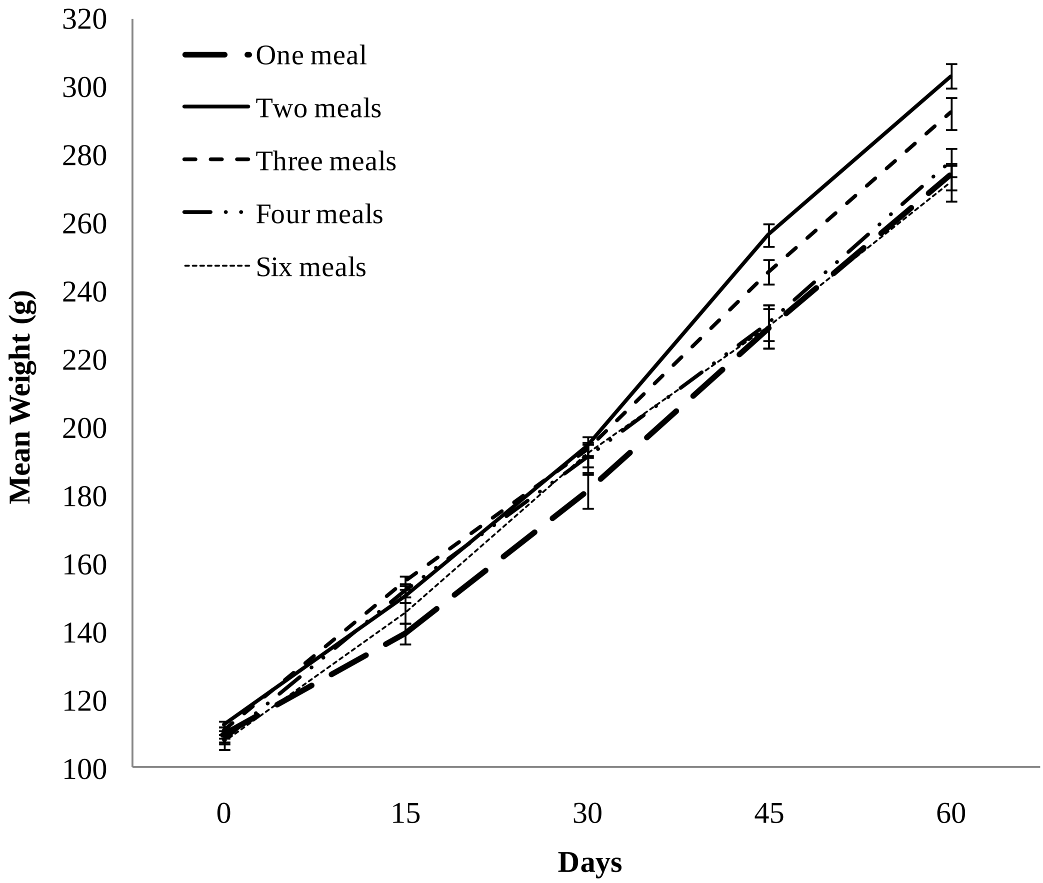

Figure 1. Mean (± SE) weight (g) of cobia (*Rachycentron canadum*) juveniles fed one, two, three, four or six daily meals for 60 days.

5. ANEXO (Normas para publicação na *Aquaculture*)

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D.M. Gatlin
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6) characterization of the actions of hormones, cytokines and/or components in intracellular signaling pathway(s) that influence nutrient and/or energy utilization.

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B.Costa-Pierce
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