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Opportunities and challenges for cobia, *Rachycentron canadum* aquaculture in the United Arab Emirates

Omer Mohamed Yousif *, Krishnakumar Krishnankuti Menon, Irshan Mohamed Sareef, Mohamed Abdulhatti Sabry, Shamal Pothodi Pothodi, Ananda Baharati Ramasamy, Hozifa Tagaldin Sagiar and Tarig Tagalsir Ali

Aquaculture and Marine Studies Center, Abu Al Abyad Island, The Private Department of the President, P.O. Box 372, Abu Dhabi, United Arab Emirates.

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Abstract

Among the many candidate local species identified for development of aquaculture in the United Arab Emirates (UAE), cobia (*Rachycentron canadum*) has the great potential for farming in floating cage systems. Successful spawning and rearing of larvae and juveniles was first achieved by the Aquaculture and Marine studies Center, Abu Al Abyad Island, Abu Dhabi in 2008. The first trial to grow cobia in near shore cages of 55 $m^3$was done in 2009 when the stocked fish reached an average weight of 2.87 kg in 12 months rearing period. Subsequently two more attempts were carried out in larger 15 meter diameter (636 m^3) cages in 2022, the results of which were not encouraging. There are many challenges for the development of cobia farming in UAE. This article highlights the current technological challenges, sustainability issues, marketing strategies and policy matters that confront the development of commercial cobia aquaculture in the UAE and offers some recommendations.

Keywords: Cobia aquaculture; *Rachycentron canadum*; United Arab Emirates; Environmental challenges

1. Introduction

The United Arab Emirates (UAE) imports up to 90% of the food it consumes, which poses a serious challenge to the country's food security when considering global food security challenges [15]. With the population projected to reach close to 11.5 million people by 2025, there is increasing pressure on food and water resources. Food consumption is currently growing at 12% and value of food imports is expected to be around US $ 8.4 billion by 2020 [21]. Fishing, once the mainstay of UAE's domestic economy for generations, is experiencing a declining trend in recent years and this is expected to further aggravate in the coming decades as a result of climate change and today statistics show that over 75% of UAE annual fish consumption of 220,000 tonnes is imported [15]. An assessment of climate change impact on marine biodiversity and fisheries in the Arabian Gulf projected higher local extinctions for UAE, with an estimated more than 26% drop in future fish catches [1, 10, 11, 35]. A recent assessment on extinction risk of marine bony fishes occurring in the Arabian Gulf revealed that overfishing affects 47% of the bony fishes, while loss of habitat caused by coastal development affects 32% and about 8.2% of marine bony fishes are severely threatened and are nearly on the brink of extinction due to a combined effect of overfishing, coastal development, climate change and pollution [6]. The UAE is proactively responding to this looming crisis by reducing fishing efforts, regulating gear and mesh size, declaring no take areas through Marine Protected Areas (MPA's) to rejuvenate the natural stocks and implementing the closed season during the breeding period [11]. Concerted efforts are also being focused on developing the nascent aquaculture segment which is expected to meet the ever increasing demand for fish and to support fish stocks [11]. Today aquaculture represents a central component of the UAE's National Food Security Strategy, with fish identified as one of its eighteen strategic food items [15]. Among the many candidate local fish species with potential to achieve the

* Corresponding author: Omer M. Yousif.

expected role of aquaculture in the UAE, the most important is the Cobia, *Rachycentron canadum* [38]. This species has been identified as having the potential for farming in floating cage systems. The purpose of this article is to identify the current technological challenges, marketing strategies, sustainability issues, and policy matters that confront the development of commercial cobia aquaculture and offer suggestions and appropriate approach to establishing and expanding this promising industry.

2. Cobia aquaculture

Cobia has gained popularity as a good candidate for aquaculture due to its rapid growth and white meat of versatile quality [3, 26]. It is considered as one of the most promising candidates for warm water marine fish aquaculture in the world. Belonging to the family Rachycentridae, cobia is the only member of the family and has nearly a global distribution, being found in the tropical and sub-tropical warm waters, except the eastern Pacific. The impressive growth rates, with fish of 6-10 kg being grown over a 12 month period under ideal conditions in parts of China, Taiwan and other Asian countries, adaptability to commercially available aqua-feeds and excellent palatability are some of the attributes that make Cobia an exceptional candidate for aquaculture [23, 31, 8]. Ever since the species was first farmed commercially in Taiwan in the early 1990's [22, 37], the industry has expanded around the world with commercial operations in the Americas, Vietnam, Thailand, USA and Australia [2, 26, 29]. The annual global cobia aquaculture production had incresed from 3,000 tonnes in 1995 to 25,373 tonnes in 2006 and 53,000 tonnes in 2018-2020 [13, 34, 4]. This substantial growth reflects a definite trend of increased production over the past 23 years. China is the dominant cobia aquaculture producer accounting to approx. 80% of global production followed by Taiwan and Vietnam. Other small commercial cobia producers are Thailand, Malaysia and Indonesia, Ausralia, Iran, Japan, Reunion Island, Central and South America and the Caribean. Pilot-scale production using submersible sea cages has also shown promising results in the Caribbean [3, 33].

The vast majority of cobia are grown out in cages or net pen in open ocean, enclosed or semi enclosed bay and estuary mouth. Production infrastrucure varies from region to region, with small traditional cages in most Asian countries to large cage systems in China and the Americas. Because of its fast growth rates, this species requires high environmental and nutritional conditions to thrive and these, by far exceed those of other commercially raised marine fish and are very difficult to meet. These high requirements explain the commercial failure of several cobia farm located in near shore, coastal areas and land-based farms including RAS [4]. In Panama and Brazil they use some new technologies for cobia grow out called the open water farming systems such as sea station and aquapods which are fully submersible systems and sit around 10m below the surface. Open Blue Sea Farms (OBSF), is the largest open water cobia farm in the world, being operated off the coast of Panama. [5, 4]. OBSF is located in the Costa Arriba region of northern Panama and is unusual because it is an offshore site 11 to 12 km from the coast that uses submerged net pens. The water depth at the farm ranges from 65 to 70 m (213 to 230 ft), and the sea pens are situated 10 m (30 to 35 ft) below the surface. OBSF also operates a local hatchery and processing facility, and harvested 1,500 MT whole weight in 2014. The majority of OBSF cobia is exported to the U.S. There is also one commercial cobia facility in Australia which produces over 100 tonnes annually,where cobia are grown in one hectare modified shrimp ponds. Raising cobia under these intensive conditions requires advanced technologies that are automated, complex and expensive to establish and operate and this in turn requires to be sold at high prices to compensate for the high production cost [4]. Studying the profitability of large submersible cages in Taiwan, it was found that the scale of operations is critical for the farming to be economically viable considering the high capital costs involved and the optimum production scale conditions were satisfied with the economic benefits of investment when 16-unit cages were operated [19].

3. Challenges to commercial production of cobia in UAE

Realizing the huge potential of cobia, the Aquaculture and Marine Studies Center (AMSC), Abu Al Abyad Island, United Arab Emirates (UAE) introduced this species in 2005 as fingerlings which were grown until they reached maturity within 3-years' time. The Center achieved the first successful spawning in the year 2008. Since then the center continued its spawning and rearing activities successfully for a number of years in the AMSC hatchery facility (Figure 1).

Cobia spawning trials under the natural hypersaline conditions of natural seawater of Abu Al Abyad Island (51 ppt), provided a clear indication of the inappropriateness of such a high salinity level for the propagation of the species. However, the results obtained under a more moderate salinity of 37 ppt demonstrated the possibility of successful spawning of cobia in Abyad Island. [39, 40].

In UAE cobia is a popular sports fish and a welcome bycatch to the commercial fishing industry. The total catch of cobia in 2021 was 800 ton representing 1.18% of the total catch (MOCCAE, personal communication). The fish is commonly sold to restuarants as kingfish. Commercial cobia aquaculture in the UAE has great potential and there are areas within the country that are geographically conducive to cobia culture like the deep waters adjacent to to the Fujairah coast and west south-east of Delma Island in Abu Dhabi [12] where large offshore cages could be installed and operated. Commercial grow out utilizing traditional sea cage methods is under consideration by few leading UAE aquaculture ventures in the private sector. Land based RAS systems could be the other option, though more research and trials are required before the ideal system and design conducive to UAE climate and conditions are standardized. Techno-economic feasibility studies are also required to convince potential investors and banks. Given all the advantages that this candidate species offers, there still exists a number of technical, biological and marketing issues that must be resolved prior to anticipating the real potential that this carnivorous species offers to UAE aquaculture.

Figure 1 Harvesting cobia juveniles at the AMSC

3.1. Brood stock spawning and nutrition

Although spawning has been achieved in captive cobia at the AMSC, Abu Al Abyad Island by administering HCG hormone intramuscularly [39], predictability of egg production was inconsistent, making it difficult for planning larval rearing and juvenile production, which is absolutely necessary for a commercially viable operation. Successful and viable spawning in captivity is a result of proper husbandry, nutrition and the existence of the appropriate environmental conditions. Proper brood stock holding and management protocols are a prerequisite to achieve predictable and consistent year round egg production. The quality and biochemical composition of the spawned eggs could vary due to genetic differences, brood stock diet, environmental factors, fish age and size as well as their health status. Clearly there is a need for in-depth research on the spawning performance and larval survival between batches.

One of the prerequisites for domestication and the establishment of a sustainable cobia aquaculture industry is the capacity to control the reproductive processes in captivity and to acquire high quality gametes which ensure healthy fingerlings for the grow-out market. This ability will allow reliable and consistent production of fingerlings; manipulation of the reproductive season through photo-thermal regulations and achieve year round egg production; and the improvement of desirable traits through selective breeding programme. In addition, spawning induction therapies will also need to be used to ensure that most of the fish being held in the tanks are actively spawning and contributing to egg production. Domestication of a new species is a long and difficult process involving access to specific skills, knowledge and technology and long term public and private funding [20, 16, 27]. Obviously a lot more research is required in the case of cobia to achieve the above spawning related goals.

Successful brood stock production and management under the existing hostile environmental conditions prevailing in Abu Al Abyad Island, calls for attaining complete control over the growth, nutrition, health status and gonadal maturation processes of the captive brood stock. To overcome the adverse environmental conditions in the open cage system and to further develop the hatchery techniques such as off-season spawning techniques (year-round volitional spawning), a complete re-circulatory aquaculture system (RAS) is being envisaged in the future to maintain the brood stock.

It is a well known fact that brood stock nutrition has significant effects on gonadal growth, fecundity, fertilization, hatching rate and viability of eggs. Superior nutrition for the broodstock will be of particular importance in ensuring yolk quality for the proper endogenous nutrition of the developing embryonic larvae which has direct implications on the quantity and quality of weaned fingerlings produced [28]. While formulations to ensure optimal fecundity, gamete quality and larval survival have been attained in other species [36], for cobia no such information is available on optimized brood stock diets, and this clearly represents an important limitation which demands immediate attention. Captive brood stock represents a major part of the investment of commercial aquaculture operations and therefore considerable efforts needs to be focused in this critical area. Healthy brood stock is a must for realizing the full potential of cobia and for the industry to flourish.

3.2. Larval and Juvenile Rearing

The development of a robust cobia aquaculture sector and its expansion is dependent on a reliable commercial supply of robust and healthy fingerlings. The live feeds offered to the early larvae continues to be predominently the traditional live feeds such as Rotifer and Artemia which have long been considered nutritionally insufficient. Larval survivals continue to be relatively poor when compared to other marine fishes. No detailed studies have been made in optimizing larval stocking densities and feeding protocols and strategies. Superior growth and survival have been observed when larvae were offered wild zooplankton [17]. In the wild, marine larvae typically feed on wild zooplankton, such as copepod nauplii and adults, which contain very high levels of HUFA's.

Micro-diets have been supplemented as a means to wean larvae earlier [14]. However, problems associated with their palatability, size uniformity, water column residency time, digestibility and ingestion rates are all areas that needs to be further standardized. It is very important to satisfy the nutritional requirements both quantitatively and qualitatively. More nutritional information at all life stages is a must to ensure the success of the hatchery industry. Clearly further studies on larval nutrition is warrented, before any cobia specific larval diets becomes available in the market. Another critical issue in the larval rearing is to design the tanks to optimize the hydrodynamic environment so as to enhance predator-prey and larvae feed interactions while at the same time taking care of tank cleaning and mixing processes [18]

3.3. Grow-out of Cobia

The first trial to grow-out cobia in UAE was conducted in 2009 in Abu Al Abyad Island. Fingerlings averaging 19.68±0.89 g body weight (BW) and 16.43±1.12 cm body length were grown-out in 5x5x2.5 m^3 (55 m^3 water volume) nearshore net cages. All cages were shaded from direct sun light with green shading materials (Figure 2).

Figure 2 Shaded 5x5x2.5 m^3 nearshore net cages

The fish were stocked at a rate of 4 fish/m^3 and were fed with floating pellet feed (54% crude protein, 10% crude fat) at a rate of 0.5 – 1% BW. Within a growth period of 12 months the average BW attained was 2.87 kg ranging in size from 1.78 to 3.86 kg (Figure 3). The feed conversion ratio attained was about 2.0 and the survival rate attained was 80% [38]. In November 2021, a second grow-out trial was conducted in Abu Al Abyad Island using four-636m^3 round (15m dia) cages. The cages were situated in one of the Island's dredge channel with an average water depth of 10m and water salinity of 41 - 42ppt (Figure 4).

Figure 3 A 2.87kg cobia harvested in the first trial in 2009

Figure 4 Cage farm at Abu Al Abyad Island

The fish averaging 66.77±15 were stocked at a density of 1.35 fish/m^3 amounting to 3,435 juveniles in the 4 cages. The fish were fed to satiation with Skretting feed 42% crude protein and 16% crude fat. The fish started dying in the cages by the end of November 2021 and continued until March, 2022 when the cumulative mortality reached 88.36% and therefore it was decided to terminate the trial and harvest the remaining fish which reached an average body weight of 460.50 g. The lowest sea bottom temperature recorded was 17 °C and the highest was 28.30 °C and the dissolved oxygen content ranged between 4.85 ppm to 8.14 ppm.

In May 2022, a third trial was conducted using one round 15m diameter cage. Cobia juveniles averaging 21.90±11 were stocked at a density of 11.80 fish/m^3 amounting to 7,500 juveniles. The fish were fed to satiation with Skretting feed 42% crude protein and 16% crude fat. The fish started dying in the cages by the end of May 2022 and continued until August 2022 when the cumulative mortality reached 57.91% and therefore it was decided to terminate the trial and harvest the remaining fish which reached an average body weight of 182.92±18 g. The lowest water temperature recorded was 33.5°C and the highest was 36.8°C and the dissolved oxygen content ranged between 3.50 ppm to 6.80 ppm (Figure 5).

When the temperature started rising above 30°C, the feed intake by the fish was observed to reduce until they completely stopped feeding at a water temperature of 35 °C. The stomach and intestines of the dead fish when tested were found devoid of any food with only bile present in the intestine and all internal organs were found to be free of any lesions or necrosis. Also, samples of the fish were subjected to parasitic, viral and bacterial investigations and they were found to be free from any parasitic infection; bacterial load was within safe limits and were negative for both viruses screened (Viral Nervous Necrosis (VNN) and Iridovirus).

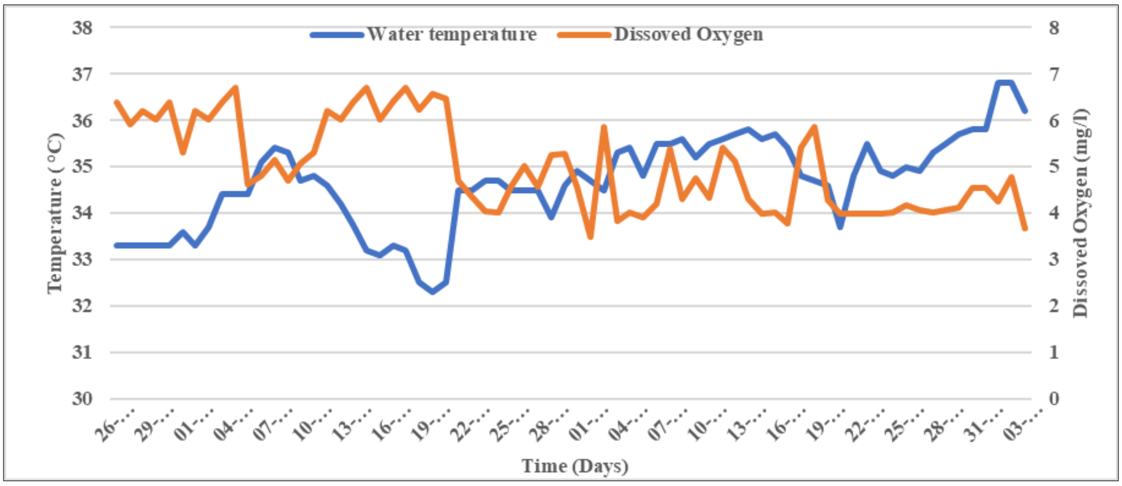

Figure 5 Water temperature and dissolved oxygen levels recorded during 2022 trials

These growth results from both grow-out trials in Abu Al Abyad Island are considered inconsistent with the impressive growth rates reported elsewhere [4] and is presumed to be due to the depressive effect of the high salinity/temperature levels prevailing in the area. Nevertheless, when comparing the growth performance of cobia with that of other marine fish species cultured in the Island, it is obvious that cobia is very much the most promising candidate for a viable aquaculture in the area. To evade the depressive effects of high salinity and temperature and make cobia aquaculture more promising in the area, it could be recommended that future trials should consider the indoor rearing of cobia during summer time, in particular during July and August, before transferring them to cages or even pond systems.

Formulated feeds for the growing fish constitutes the most expensive operating variable for the producers. Because cobia is a recent entrant in the industry, quantitative nutritional data for this species have only started to accumulate recently. Presently cobia farms are using feeds tailor made for other species. Productivity gains can only be attained by having a specifically tailor made formulation for cobia. Fish meal is generally considered to represent the "gold standard" dietary protein source for carnivorous fish like cobia. Because fish meal represents a finite source, it is not surprising to find aquafeed industry is seeking alternative protein sources. Cobia appears well suited and able to accept alternate protein sources as replacement for fish meal [40] Higher fillet textures have been reported for cobia fed on alterante plant proteins [24]. However the possible negative impacts of alternative protein sources on the final product quality of cobia is yet to be studied in detail. The possible impacts of these new formulations upon the end product quality must be determined and validated so that products specific to certain niche markets (Organic sector) can be produced.

Genomics will increasingly play a major role in all the sectors of the industry and will certainly impact on selective breeding programmes, enhance our understanding of digestive physiology and help design feeds for larvae, juveniles , adults and brood stock [25]. It will also play an important part in selecting sustainable alterate protein and lipid sources for feeds and ultimately help design cobia specific feeds and product end quality issues of developing designer fish for exclusive niche markets.

Cobia are known to tolerate low salinities and grow well [30]. It would be worthwhile exploring the possibilities of growing cobia inland in UAE using low saline waters from unused agricultural bore wells. This could offer the potential to produce cobia to market size away from the sea coast. However refinements will be required in the diet formulations required with respect to ion/salt concentration to achieve desired growth.

3.4. Diseases

Disese is recognized as the single most important factor limiting expansion of cobia operations. Cobia are known to succumb to the usual array of parasites and diseases found in other warm water species and disease is recognised as the most important limiting factor in the expansion of cage farming operations [13]. Among the most common diseases reported to cause mass mortality of cobia at all stages of their life cycle are those caused by the parasitic *Amylodinium* sp. and bacterial Photobacterium sp. [3]. At the AMSC, Abu Al Abyad Island, the issue of cobia mortality was observed to occur during all culture phases from hatchery to grow-out in the sea cages. To investigate the reasons behind these mortalities, a comprehensive pathological investigation was carried out by the AMSC using the molecular, microbial and histopathological techniques. The fish were screened for the viruses Viral Nervous Necrosis (VNN) and Iridovirus using real-time PCR and all samples were found negative from these viruses infection. Microbial analysis for total bacterial and total vibrio load revealed that moribund cobia had relatively high bacterial and vibrio load when compared to active ones indicating a possible bacterial infection. Bacterial investigation of the liver tissue from moribund fish confirmed the presence of four bacterial isolates (*Vibrio alginolyticus*, *V.fluvialis*, *Pseudomonas fluorescens and Staphylococcus*. *Sp.*). Treating the infected fish with medicated diet (100 mg Oxytetracycline/kg) was relatively effective. Attempts to vaccinate cobia brood stock and 53 and 96 days post hatch fingerlings against VNN and vibrio (Hipra Laboratories, Spain) were not effective. Similarly, Benetti et al. (4) reported that attempts to develop reliable vaccination protocols against *Streptococcus* spp. and *Vibrio* spp. in cobia had limited effect. The histopathology tests of different internal organs (liver, kidney, spleen, brain and gill) of the moribund fish showed a high amount of lipid deposition in the hepatocytes (liver steatosis). The steatosis condition was present in both active and moribund cobia, but it was more prominent in the moribund cobia. The nodule formation, bile duct deformation and sinusoidal collapse were also observed prominently in moribund fish. The kidney also showed localized renal deformation in moribund cobia prominently. Nutritional imbalance (high level of lipids in the formulated diet), feeding to satiation (over feeding) and the environmental stresses (high temperature associated with salinity) were thought to be the direct reasons for the excess deposition of fat inside the hepatocytes leading to liver steatosis.

There is a need to implement more stringent disease screening and preventative measures for hatchery and grow-out facilities throught the production cycle. This will essentially include development of specific pathogen free brood stocks, greater use of biosecure RAS systems, dietary immunostimulants and specific bacterial and viral vaccines for cobia.

3.5. Environmental challenges

Development of offshore cobia aquaculture inside the Arabian Gulf also brings in environmental challenges and calls for an appropriate policy decisions on carrying capacities. Although some researchers believe that due to the constant movement of the water currents which, very likely, carry the waste from the cages to other places, the cobia farms are environmentally sustainable and the activity is possibly not causing impacts associated with the residues produced by the fish in the benthic community of unconsolidated substrate [9] and have limited influence on sea water environmental quality [32], a proper assessment of the sea site in terms of depth and water currents is highly recommended to determine the appropriate carrying capacity for an environmentally sustainable operations.

3.6. Processing and marketing

In general the market for cobia is highly variable, driven by low production and underdeveloped markets. The market potential of cobia in UAE is poorly understood, and this needs to be better defined to enable cobia aquaculture to fulfil its expected potential

Although the domestic market is very small at present, there exists export potential for cobia produced in the UAE to service markets in the Gulf Cooperation Council (GCC), Europe and Asia with premium grade product. Processed products include head-on/off, whole/gutted, fresh/frozen, smoked fillet. Products exported to Japan and Korea from Taiwan is mainly for sashimi. In the USA and EU, farmed cobia have entered the white table cloth sectors with high acceptability for premium prices. Although the demand and consumption of cobia is mostly in Asia, it is also recognised as a fish readily accepted by Western palates, as evidenced by its position in high-end markets and restaurants in the USA, Europe and Australia. Live markets has been attempted on a small scale in Asia with smaller sized individuals. Production of value added forms like breaded cobia and cobia based fish patties and sticks for institutional and conventional markets can be considered by producers and processors. However this will require a high quality, safe and wholesome product produced using environmentally sustainable methods with absolute traceability for successful supply chain management [7].

3.7. Asset Insurance

Development of offshore cage fish farming being capital intensive, is a high risk activity. Scaling up the operations will further increase capital and operating costs. All the assets of the operations being in the sea far away from the mainland, is a serious challenge to safety of the biological stock from poaching and natural calamities and equipment asset risk control and management. Financial institutions could be reluctant to approve loans for such a risky activity. Investors need to have a comprehensive evaluation, and planning before investments are made.

4. Conculusion and recommendations

The aqualture merits possessed by cobia make it a potential commercial species in the UAE. However, despite these ambitions, its aquaculture development in UAE faces many challenges. The most challenging factors in UAE are the harsh environmental conditions that prevail during the summer time, where water temperature reach up to >33°C a level that cobia can not survive. To overcome this challenge, it is highly recommended to grow cobia in areas within the country that are having deep waters like the west south-east of Delma Island in the Emirate of Abu Dhabi where water depth reaches up to 30 meters. Also, farming cobia under intensive conditions requires the availability of adequate feeds that satify their metabolic needs, On the other hand there are urgent needs for research in the areas of nutrition, fish health and welfare, genetics, production of high quality juveniles and market development.

Compliance with etical standards

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Disclosure of conflict of interest

The authors declare no conflict of interest.

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