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Relative Gut Length and Gastro-somatic Index of *Acanthopagrus arabicus* (Iwatsuki, 2013) from the Offshore Waters of Pakistan

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Abstract

Relative gut length, Zihler's index, and Gastro-somatic index of Acanthopagrus arabicus were studied to investigate its feeding intensity and feeding habit, by collecting 240 samples of fishes from two fishing harbors of Pakistan from September 2017 to August 2018. According to the results, fish mean total length ranged from 16.26 ± 2.83 cm (in June) to 30.89 ± 5.16 cm (in September), and mean total weight ranged from 77.70 ± 42.25 g (in June) to 486.80 ± 237.28 g (in November). The total length and gut length of A. arabicus have a strong statistical relationship ($P < 0.05$). In A. arabicus, the overall relative gut length (RGL) values were ranged from 0.69 to 2.63 with a mean value of 1.57 ± 0.31. The RGL lowest (1.35) and highest (1.70) value was analyzed in the size groups ranging 12.0 - 16.0 cm TL and 24.1 - 28.0 cm TL respectively. However this value is not much greater than 1, A. arabicus could be described as an omnivorous feeding habit in coastal waters of Pakistan. The temporal changes in the feeding intensity of A. arabicus were found as the Gastro-somatic index (Ga-SI) presented a significant difference during the twelve months (ANOVA, $P < 0.05$). The Gastro-somatic index lowest value was found in January (1.55 ± 0.59) and highest in August (5.66 ± 3.26). This type of study is beneficial for aquaculture as well as assessing the ecological role of A. arabicus along with its position in the food chain of Pakistani coastal waters.

Keywords:
Acanthopagrus arabicus, gastro-somatic index, relative gut length, Pakistan.

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Introduction

The most vital function of an animal to be fit physically and functional is feeding. Reproduction, development, growth, etc. all these important functions are carried out at the cost of the energy,

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which enters the organism in the form of its food. Fish growth is directly affected by the quality and quantity of food taken whereas reproduction and mortality are affected indirectly in any aquatic system (Wootton, 1990). Observation of fish food is usually very significant for the understanding of its nutritional demands, its connection with other organisms, its trophic interrelationship in an ecosystem, and the possible potential for its aquaculture. Besides this, for fish stock estimation as well as for ecosystem modeling data on the feeding behavior of fishes is crucial (Salavatian et al., 2011).

Fishes can manipulate their gut in response to changes in food quality and body size. Generally, morphometric patterns are greatly significant for particularly eco-morphological observations (Motta, 1988). Species of fishes with various body shapes (for example, elongated, compressed, or deep-bodied) possess gut length in various sizes since deep-bodied fishes usually have more space in their peritoneal cavities to house more longer, greatly coiled guts (Montgomery, 1977; Barton, 1982; Kramer & Bryant, 1995a). However, variability in body mass can also create ambiguous results in comparisons of gut length, as fishes with a faster growth rate tend to be heavier and display longer guts than those with a slow growth rate (Kramer & Bryant, 1995b). The relative gut length (RGL) index is an indicator that offers knowledge on the various types of food consumed. It is helpful in comparisons among fishes with different diets, for example, herbivores, carnivores, and omnivores (Al-Hussaini, 1949). Gastro-somatic index (Ga-SI) is the scale of gut-weight with body weight. This is a useful tool to discover the feeding intensity of a fish (Desai, 1970). The variation in feeding intensity can be detected by monthly fluctuation in data of Ga-SI and for defining the environmental and physiological effects on feeding habits.

Acanthopagrus arabicus (Iwatsuki, 2013) fish species is exploited for trade and nutritive purposes and has a good market value, sold fresh in markets. This species is important in both traditional fisheries and marine aquaculture in Pakistan (Ahmad et al., 2018). *A. arabicus* consume mostly echinoderms, worms, crustaceans, and mollusks as food. (Bauchot & Smith, 1984). According to Gerking (1994), various fish species belonging to different taxonomic groups tend to adapt to several food sources, as well as to modify their feeding behaviors to respond to seasonal, diurnal, and temporal changes in food availability. However, information regarding food and feeding behavior along with RGL and Ga.SI of *Acanthopagrus arabicus* is meager. Though several studies had been reported on the food and feeding habits of species belonging to the genus *Acanthopagrus* from different parts of the world, such as *Acanthopagrus butcheri* from Western Australia (Norriss et al., 2002), *A. schlegeli* from Hong Kong (Nip et al., 2003), from Iran (Sourinejad et al., 2015), *A. latus* from Northern Persian Gulf (Vahabnezhad et al., 2016), *A. bifasciatus* from Egypt (Mehanna et al., 2017) and *A. berda* from Calicut, southwest coast of India (Thomas et al., 2018). The only reported study on food and feeding habits of *A. arabicus* from the coast of Karachi, Pakistan was by Riaz (2019) but none of the study conducted from Balochistan, Pakistan. Therefore realizing *Acanthopagrus arabicus* economic significance and due to the limited dietary information, the current study was consequently accomplished to add the knowledge about the feeding biology of *A. arabicus* (yellowfin seabream) in the coastal waters of Pakistan (Northern Arabian Sea). This type of study is beneficial for successful fish farming as well as assessing the ecological role of *A. arabicus* along with its position in the food chain.

Materials and Method

For the present study *Acanthopagrus arabicus* fish were bought each month from the landing station of Karachi and Sonmiani fish harbors, situated in Sindh and Balochistan provinces respectively, for the period of one year from September 2017 to August 2018 (Figure 1). A sample of 15-20 specimens (nearly 3 to 4 kg) of this species was randomly selected from the batch of fish in the containers at the auction hall. The fishes were transported to the laboratory in polyethylene bags filled with ice. Total 240 fishes were collected and then evaluated biometrically. The total length and the total weights of the sampled fishes were measured to the nearest 0.1 cm and the nearest 0.1 g, respectively. The specimens after cleaning properly through freshwater in the laboratory were dissected and the guts were removed. The length of the gut was measured to the nearest 0.01 cm and the weight of the gut with its contents was weighed to the nearest 0.01 g precision (Figure 2). The Gastro-somatic index (Ga-SI) for each month and season was calculated as described by Desai (1970):

Gastro-somatic index (Ga-SI) = Weight of the gut / total weight of the fish × 100

The Relative gut length (RGL) was calculated to deliver classification (herbivore, carnivore, and omnivore) in the fish of different sizes. RGL was estimated by the following equation (Al-Husaaini, 1949):

Relative gut length (RGL) = length of the gut / total length of the fish

But RGL index ignores differences in body mass. According to Zihler (1982) body mass is a more suitable measure than length for interspecific assessments of gut length allometry. For this purpose, we also estimated Zihler's index (Zihler, 1982):

ZI = gut length (cm) / fish body weight (g) 1/3

The regression equation Y = a + b X, was practiced to discover the relationship between the total length of fish (X) and gut length (Y) by using a nonlinear regression model that is an important method in allometric assessment as it simultaneously inspects variation in both X and Y variables (Ebert & Russell 1994). The a and b values, which are constant, are calculated from log10 converted values of X and Y, that is, log10 Y=a+b log10 X, as defined by Zar (1996). The student's t-tests were used to confirm the hypothesis of isometry (b=1).

Statistical differences in RGL, ZI, and monthly Ga-SI were evaluated by analysis of variance (ANOVA, $\alpha = 0.05$), while Tukey's test was performed as post hoc analysis. Pearson's correlation was computed between different variables.

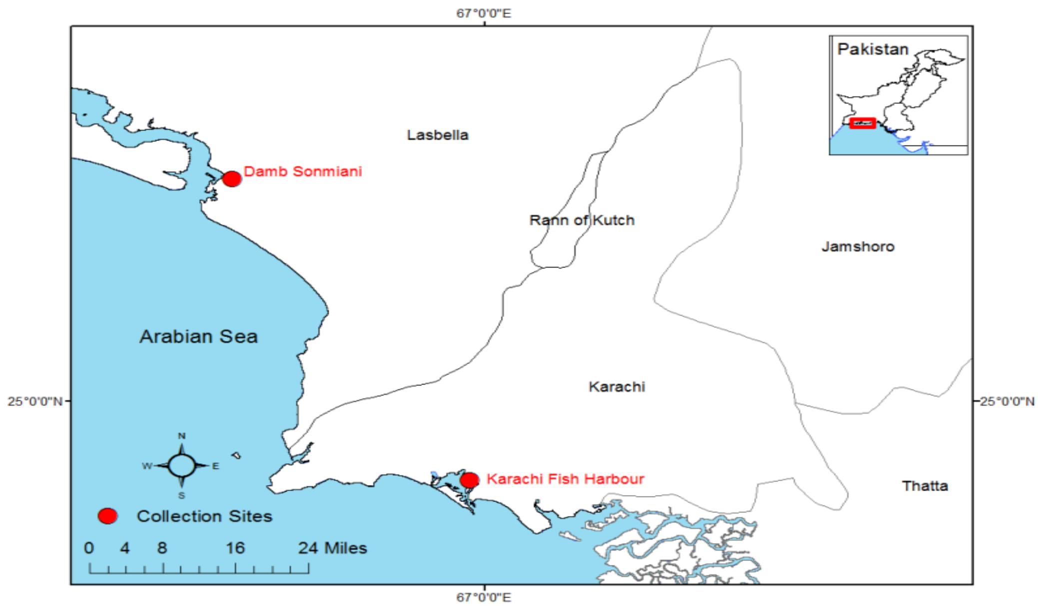

Figure 1. Map showing the location of sample collection of *Acanthopagrus* arabicus from Pakistan.

Figure 2. The gut length and gut weight of *Acanthopagrus arabicus* were measured during the study period.

Results

In the present study, 240 samples of A. arabicus were inspected. According to the results, fish total length ranged from 12.00 to 41.00 cm with minimum mean length (16.26 ± 2.83 cm) in June and maximum (30.89 ± 5.16 cm) in September. Fish total weight ranged from 31.00 to 1236.00 g with minimum weight (77.70 ± 42.25 g) in June and maximum (986.80 ± 237.28 g) in November. (Table 1).

Table 1. Biometric data of *Acanthopagrus arabicus* in the Pakistani coastal waters from September 2017 to August 2018 (Mean ± SD) (N = 240).

Month	**Total Length (cm)**	**Total Weight (g)**	**Month**	**Total Length (cm)**	**Total Weight (g)**
September	30.89±5.16	439.60±281.78	March	24.27±9.06	311.75±299.08
October	28.15±4.42	311.95±87.50	April	24.43±8.82	318.45±298.96
November	29.76±5.02	486.80±237.28	May	17.03±3.84	98.15±69.01
December	26.12±2.56	285.90±67.16	June	16.26±2.83	77.70±42.25
January	26.23±2.82	296.40±84.84	July	18.81±5.07	142.80±131.98
February	25.24±3.04	279.75±91.73	August	19.30±4.88	145.40±104.48

The relationship between total length and gut length of *A. arabicus* was strongly related ($P < 0.05$). The student's t-test showed isometric growth ($b = 1$, $P < 0.05$). The regression equation was obtained as $Y = 0.8120 + 1.2035TL$. The degree of variation (r^2) in gut length was 78.7% (Figure 3). There is a significant positive correlation between total length and gut length ($r = 0.89$, $p < 0.05$).

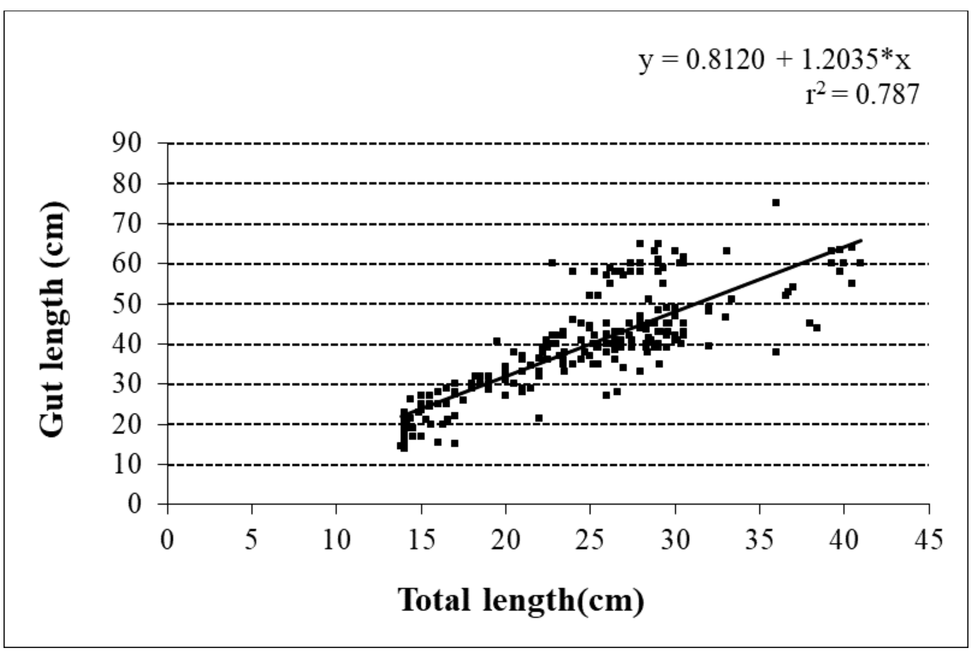

Figure 3. Regression between total body length and the gut length in *Acanthopagrus arabicus.*

In *A. arabicus*, the overall RGL value ranged from 0.69 to 2.63 with a mean RGL of 1.57 ± 0.31. However, RGL values in different size classes ranged between 1.35 - 1.70. The lowest (1.35) and highest (1.70) value of RGL was analyzed in the size groups ranging 12.0 - 16.0 cm TL and 24.1 - 28.0 cm TL respectively (Figure 4), representing that *A. arabicus* displays omnivorous feeding habit in coastal waters of Pakistan. However, ZI values were varied from 0.01 to 0.65 with a mean value of 0.11 ± 0.13. The lowest value (0.02) and the highest value (0.33) of ZI were found in the size groups 12.0 - 16.0 cm TL and 40.1 - 44.0 cm TL respectively (Figure 4). In the current study, Zihler's index (ZI) was characterized in a range related to carnivore fishes. The RGL and ZI values demonstrated significant differences within the size groups of total length (ANOVA, P < 0.01).

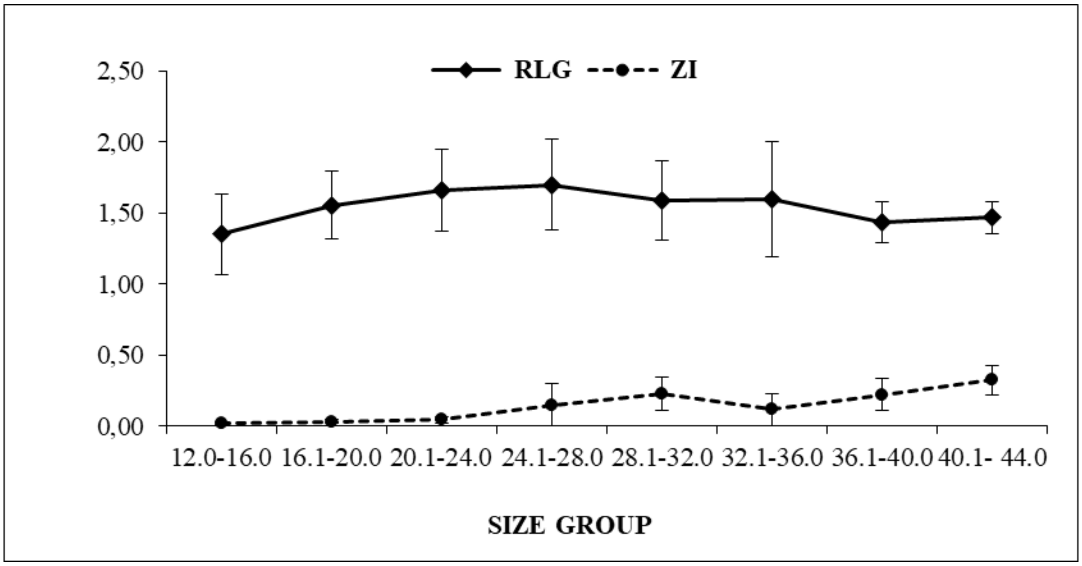

Figure 4. RGL and ZI at different size groups based on TL of *Acanthopagrus arabicus.*

Ga-SI values are demonstrated in Table 2 and Figure 5. The temporal changes in the feeding intensity of *A. arabicus* were found as the Ga-SI presented a significant difference during the twelve months (ANOVA, P < 0.01). The Ga-SI lowest value was found in January (1.55 ± 0.59) while highest in August (5.66 ± 3.26). The annual mean value of Ga-SI was 3.22 ± 1.93. On a seasonal basis the highest value of Ga-SI was found in summer (4.16 ± 2.43) and its lowest in the winter season (1.98 ± 0.91).

Table 2. The average Ga-SI was observed in *Acanthopagrus arabicus* from September 2017 to August 2018 (N = 240).

Season	Autumn			Winter			Spring			Summer		
Ga-SI	2.32±0.84			1.98±0.91			3.81±1.48			4.16±2.43		
Month	**09**	**10**	**11**	**12**	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**
Ga-SI	1.82± 0.85	1.81± 0.75	2.82± 0.59	2.42± 1.03	1.55± 0.59	1.96± 0.88	3.86± 1.53	3.16± 1.44	4.41± 1.25	5.07± 1.78	4.07± 0.99	5.66± 3.26

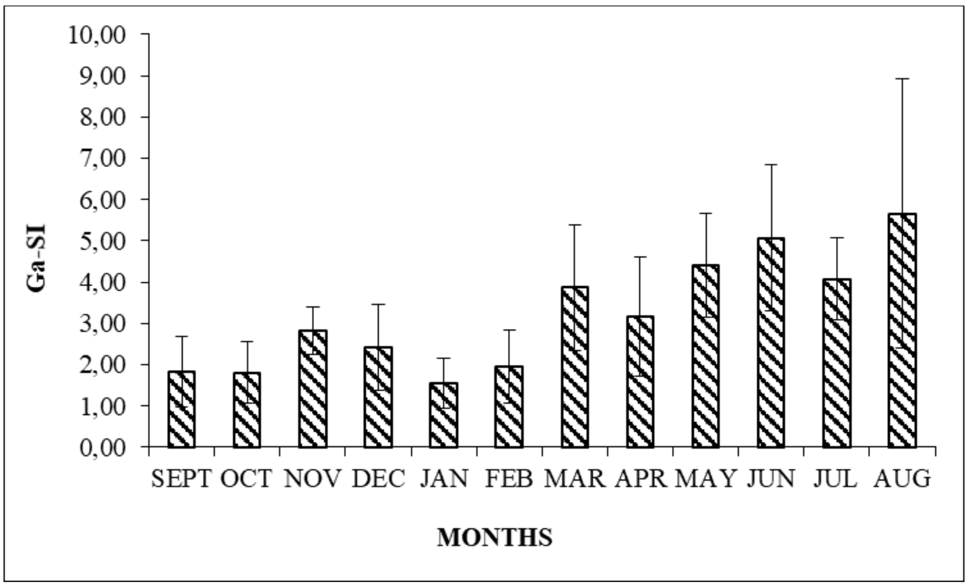

Figure 5. Ga-SI of *Acanthopagrus arabicus* during the year September 2017 to August 2018.

Fish body weight demonstrated a positive correlation with total length, gut weight, and gut length while representing a negative correlation with RGL, Ga-SI, and ZI. Total length showed a positive correlation with gut weight and gut length while negative with RGL, Ga-SI, and ZI. Gut weight only exemplifies a positive correlation with gut length although other factors showed a negative correlation. Gut length showed a negative correlation with RGL, Ga-SI, and ZI while others showed a positive correlation (Table 3).

Table 3: Pearson's correlation coefficient of the variables under study in *Acanthopagrus arabicus* from Pakistan

Variables	Fish weight	Fish TL	Gut weight	Gut length	RGL	Ga-SI	ZI
Fish TL	0.89						
Gut weight	0.87	0.69					
Gut length	0.65	0.80	0.47				
RGL	-0.14	-0.18	-0.10	-0.17			
Ga-SI	-0.44	-0.62	-0.06	-0.56	-0.01		
ZI	-0.65	-0.83	-0.48	-0.76	0.25	0.64	

Discussion

In the present study, the relationship between gut length and body length was observed as isometric growth. According to Ribble & Smith (1983) and Kramer & Bryant (1995a), there is good to have allometric growth of gut length, as isometric gut growth would result in the minimized capacity of meeting the metabolic requirements of any fish. This theory has been suggested both for freshwater fish species (Ribble & Smith, 1983; Kramer & Bryant, 1995a) and marine species (Honda, 1984; Eggold & Motta, 1992; Benavides et al., 1994). Our result is in contrast with those that reported an allometric relationship between gut length and body length (Perez-Espana & Abitia-Cardenas, 1996; Ward-Campbell et al., 2005; Karachle & Stergiou, 2010).

It is mostly recognized that relative gut length RGL < 1 designates carnivorous, 1 < RGL < 3 designates omnivorous, while the value of RGL > 3 designates herbivorous diet (Al-Hussaini, 1949). In the current study, the average relative length of gut in *A. arabicus* is calculated to be 1.57 ± 0.31 cm. However this value is not much greater than 1, *A. arabicus* could be described as an omnivorous feeding habit. Figueiredo et al. (2005), Sourinejad et al. (2015) and Thomas et al. (2018) also documented sparids species as omnivores.

Although, variation of RGL values was less in different size groups, yet lowest value was observed in the size group of 12.0 - 16.0 cm TL (1.35) and the highest in 24.1 – 28.0 cm TL (1.70). It is observed that the RGL value increases with an increase in size that displays the change in feeding habits i.e. from carni-omnivorous to herbi-omnivorous but a declining value in 36.1 – 40.0 cm TL indicated its carni-omnivorous habit, which possibly may be due to the availability of food in the habitat. A significant difference in RGL and ZI values was also observed with different size groups (P < 0.01). Hence it was concluded through the present study that changes in feeding habits from smaller to larger size groups were inferred by growth in *A. arabicus*.

To investigate whether bodyweight may more perfectly explain the link between the length of the gut and the size of the fish, this study also evaluated Zihler's Index (ZI). The categorization of ZI values for fishes with various body masses was investigated by Kramer & Bryant (1995a). The fishes with body masses vary from 0.3 to 3.0 g, a ZI of 2.3 – 3.2 a carnivore, 2.4 – 5.8 an omnivore, and 11.6 – 55.0 specify as an herbivore in feeding habit. *A arabica* had an exceedingly low ZI mean value of 0.11 ± 0.13, referred to as carnivores. Though the RGL value was also not much exceed from 1, shows results are almost the same with both indices. Secondly in our study, fishes have greater body masses while the ZI scale showed more accurate values with low body masses. Moreover, RGL and ZI are basic measures of gut morphology of the fish and have been utilized as potential indices on a basis of its gut length to recognize the dietary strategy of a fish, but there are some limitations for their use. For example, these indices (RGL and ZI) can generate deceptive results when neglecting the phylogenetic relationships of the fishes which are compared (Elliott & Bellwood, 2003).

In *A. arabicus* maximum values of feeding activity in summer may be associated with temperature and higher abundance of benthic organisms (Pallaro et al., 2003). The presence of rich nutrients in coastal waters of the Arabian Sea (Qasim, 1977; Banse, 1987) or the suitable environmental conditions in warmer months and satisfactory food stock availability over a larger period of the year might lead to high feeding intensity during summer. The gastro-somatic index in fishes reduced in the reproduction period and increased before and after reproduction, representing an inverse relationship between feeding intensity and reproduction season (Azh et al., 2015; Sourinejad et al., 2015; Vahabnezhad et al., 2016; Kurbah & Bhuyan, 2018; Thomas et al., 2018). The result of the present study is in agreement with that fact in the feeding habit of *A. arabicus* in Pakistan. According to Riaz (2019), *A. arabicus* reproduction season is in winter (from November to February), and we have the least gastro-somatic index in winter.

This study reveals that *A. arabicus* is an omnivore in feeding habit and the feeding activity of *A. arabicus* changed concerning the season and size of fish. This study anticipated the primary study of the feeding biology of *A. arabicus* in Pakistan. Additional research would be appreciated to study further aspects about their feeding and dietary strategy.

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Conflict of Interest

The authors declare that they have no competing interests.

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