Table 5. Ergonomic evaluation of the weeders

Parameters	Weeder type		
	T	*S*	*V*
Mean HR (beats min^{-1})	130	124	124
VO_2 consumption (l min^{-1})	0.97	0.90	0.90
EC (kJ min^{-1})	20.35	18.82	18.78
ODR	6.04	5.42	5.26
BPDS	39.2	36.8	35.2

ODR, Overall discomfort rate; BPDS, Body part discomfort score.

perform the task. Among the developed weeders, *V*-shaped blade weeder performed well as the tip of the blade penetrates easily into the soil and cuts the weeds by sliding along the cutting edges. It offers less frictional resistance between blade and weed stem, and hence, operation is easier and consumes less energy.

The generated data gives a new design limit to manually operated tools. The developed weeders perform better than existing weeders in terms of field capacity, operational comfort and physiological responses. Design creteria drawn in this research will satisfy the requirement.

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Weight–length relationship and Fulton's condition factor of the alligator pipefish, *Syngnathoides biaculeatus* (Bloch, 1785) from the Southeast coast of India

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The present study provides information on weight–length relationship (WLR) and Fulton's condition factor (*K*) of the alligator pipefish, *Syngnathoides biaculeatus* (Bloch, 1785) sampled from Palk Bay (PB) and Gulf of Mannar (GoM) regions, southeast coast of India. The pooled estimate for the parameter *b* of the WLR for *S. biaculeatus* ($n = 217$) was determined to be 1.75, indicating the negative allometric growth pattern ($b < 3$). The *K* values ranged from 0.65 to 1.35 (pooled, 0.84) and from 0.68 to 1.27 (pooled, 0.85) for populations of *S. biaculeatus* collected from PB ($n = 120$) and GoM ($n = 97$) respectively. The results may help address the concerns of conservation of *S. biaculeatus* in the wake of habitat loss and/or incidental by-catch.

Keywords: Allometric growth pattern, condition factor, population biology, *Syngnathoides biaculeatus*, weight–length relationship.

THE alligator pipefish or double-ended pipefish, *Syngnathoides biaculeatus* (Bloch, 1785) is listed as 'Data Deficient' in the Red List of Threatened Species by the

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International Union for Conservation of Nature (IUCN)[1]. This listing is due to the absence of comprehensive biological data and therefore calls for more extensive study related to its population biology.

S. biaculeatus has a wide geographic distribution throughout the Indo-Pacific region in seagrass meadows[2] and is currently represented by a single species under the genus, *Syngnathoides*. Among syngnathid fishes reported from Palk Bay (PB) and Gulf of Mannar (GoM) regions, southeast coast of India, *S. biaculeatus* is most dominant[3]. The usage of this species in traditional Chinese medicine (TCM) trade has been well documented[4,5]. Furthermore, *S. biaculeatus* is also traded as popular aquarium fish. The TCM and marine ornamental fish trades coupled with habitat loss are threatening wild populations of *S. biaculeatus*[6].

Weight–length relationship (WLR) is important in fishery biology and stock assessment of aquatic species as it helps in understanding a wide number of parameters such as estimating growth rates and age structure. Fulton's condition factor (K) is a useful index for monitoring of feeding intensity, age and growth rate in fish and assessing the status of the aquatic ecosystem in which the fish live[7]. Some previous studies on *S. biaculeatus* had focused on its life-history stages[8–11] and antioxidant properties[12]. A WLR study of *S. biaculeatus* by Barrows *et al.*[11] was restricted to the determination of parameter b from coastal waters of Papua New Guinea. Dhanya[10] provided information on WLR in *S. biaculeatus* from a single locality (PB). Although WLR and K value can reflect the growth conditions, an analysis that combines these, however, has not been carried out in *S. biaculeatus*.

To address these research gaps, the present study provides a comprehensive analysis of biological parameters (WLR and K) in *S. biaculeatus* populations sampled from two different localities (PB and GoM) in the southeast coast of India.

A total of 235 dead *S. biaculeatus* (78 males, 18 egg-bearing or pregnant males, 101 females and 38 juveniles) fishes landed as by-catch were subjected to WLR and K analysis (Figure 1). In the PB region, fishes landed as by-catch ($n = 131$) in wind-driven country trawl (Thallu madi), mainly operated for crab/shrimp fishing at Mullimunnai (9.65N; 78.97E) and Thondi villages (9.77N; 79.00E) and fishes landed as by-catch ($n = 104$) in wind driven country trawl and shore-seine nets operated at Tuticorin (8.79N; 78.16E) and Mandapam village (9.24N; 78.90E) in the GoM region formed the study material. Collections were made during February 2015. All collected specimens were preserved in 70% ethanol prior to transportation to the laboratory for weight and length measurements. Species identification was verified according to Dawson[2] and Murugan *et al.*[3].

All collected specimens ($n = 235$) were washed in running water and measured for total length (TL, cm) from the tip of snout to the end of tail[13] and total wet weight (WW, g). The WLR in *S. biaculeatus* was established, separately for males, females, juveniles and total population (pooled) from both regions (PB and GoM) using the formula $WW = a\text{TL}^b$ and linear regression analysis $\log WW = a + b \log \text{TL}$, where W is the wet weight, TL the total length, a the intercept of the regression curve and b is the regression coefficient (slope). The presence or absence of a brood was used to determine pregnant and non-pregnant proportion of males[7]. Due to additional weight of incubating eggs, egg-bearing males ($n = 18$) were not included in the WLR analysis ($n = 217$). Females were identified by the presence of white zigzag pattern on the ventral side accompanied by 15–20 blue dots[8]. Often distinguishing between non-brooding males and females is not possible in those individuals of less than 155 mm TL; in such cases they are considered as juveniles[11]. The regression line was computed by the method of simple least-square regression analysis using Microsoft Office Excel 2007. Student's t-test was applied to determine whether the parameter b obtained from the linear regression differed significantly from the isometric figure of 3. The significant difference in regression coefficient R^2, intercept a and regression slope b between male and female specimens collected from the PB and GoM regions was verified through analysis of covariance

Figure 1. Photograph showing dorsal (***a***, female and ***b***, male) and ventral (***c***, female and ***d***, male) view of alligator pipefish, *Syngnathoides biaculeatus*. Note the white zigzag pattern and blue dots on the ventral side of female individual.

Table 1. Descriptive statistics and weight–length relationship (WLR) parameters for the alligator pipefish, *Syngnathoides biaculeatus* collected from Palk Bay and Gulf of Mannar regions, Southeast coast of India

Locality	Gender	*N*	WW, mean ± SD ($WW_{min} - WW_{max}$)	TL, mean ± SD ($TL_{min} - TL_{max}$)	*a*	*b*	SE of *b* (95% CI of *b*)	Coefficient of determination (R^2)	Fulton's condition factor (*K*)
PB	Male	41	3.99–6.92	16.0–25.0	1.03	1.17	1.08–1.27	0.94	0.69
	Female	57	3.79–6.73	15.9–23.0	0.17	1.56	1.42–1.71	0.89	1.08
	Juvenile	22	1.59–6.92	9.0–14.5	–2.59	1.40	1.20–1.60	0.91	1.35
	Pooled	120	1.59–2.82	9.0–25.0	–1.53	1.75	1.67–1.83	0.94	0.84
GoM	Male	37	4.57–6.87	16.5–25.0	–0.73	1.14	1.02–1.26	0.92	0.68
	Female	44	3.67–6.28	15.9–22.0	–1.32	1.61	1.43–1.80	0.87	0.84
	Juvenile	16	1.49–2.78	9.0–14.0	–1.08	1.31	1.08–1.54	0.91	1.27
	Pooled	97	1.49–6.87	9.0–25.0	–1.52	1.75	1.67–1.84	0.94	0.85
All individuals (PB + GoM)		217	1.49–6.92	9.0–25.0	–1.53	1.75	1.69–1.81	0.94	0.83

N, Sample size; WW, Wet weight (g); TL, Total length (cm); *a*, Intercept of the regression; *b*, Regression coefficient (slope); CI, Confidence interval.

(ANCOVA). The level of significance was tested at 5.0%, represented as $P < 0.05$. Comparative assessment of WLR analysis of juveniles with that of males and females was not carried out statistically due to small sample size of the former, however they were considered for pooled analysis. Student's *t*-test and ANCOVA were performed using GraphPad Prism 5.0 statistical software.

The Fulton's condition factor (*K*) determines the physical and environmental conditions of fish and is used for comparing the condition, fatness or well-being. *K* was calculated[14,15] from the equation, $K = 1000\,W\,TL^{-3}$, where *W* is the weight of fish (g) and TL is the length of fish (cm). Difference between *K* values obtained for male and female fishes of the two regions (PB and GoM) was verified through ANCOVA.

A total of 217 specimens of *S. biaculeatus* (78 males, 101 females and 38 juveniles) collected from the PB and GoM regions were subjected to WLR analysis. Table 1 presents the estimated parameters of the WLR (number of fish (*n*), size range and weight range), the coefficient of determination (R^2) and Fulton's condition factor (*K*). The estimated regressions of WLR relationships for both male and female were significant ($R^2 > 0.95$). Results of Student's *t*-test revealed a negative allometric growth in both male and female of *S. biaculeatus*, with no significant differences in the parameter *b* between male and female ($P > 0.05$). Furthermore, ANCOVA test also revealed no significant differences in regression coefficient, intercept and regression slope of male and female fishes from the PB and GoM regions ($P > 0.05$). Overall, the parameter *b* of *S. biaculeatus* collected from the two regions was estimated to be 1.75. The WLR of *S. biaculeatus* can be described by the following equation; $W(\text{g}) = -1.52 \times TL^{1.75}$ (cm).

The calculated *K* value ranged from 0.65 to 1.35 (0.83 for pooled samples) and from 0.68 to 1.27 (0.85 for pooled samples) for the PB and GoM regions respectively. ANCOVA test also showed no difference in *K* values of male and female fishes from both regions ($P > 0.05$).

In the present study, populations of *S. biaculeatus* showed negative allometric growth pattern ($b = 1.75$; $n = 217$). In contrast, Dhanya[10] reported relatively high *b* (males, 3.17; females, 3.00 and juveniles, 2.48) from a WLR study of a larger population size of *S. biaculeatus* (400 males, 347 females and 234 juveniles) from the PB region. Barrows *et al.*[11] reported a very high *b* (4.07) for *S. biaculeatus* ($n = 41$; 18 male, 21 females and 2 juveniles) collected from Bootless Bay, Papua New Guinea. Plausible explanations for such high *b* as reported in these previous studies may perhaps be due to the inclusion of pregnant males in the WLR analysis and favourable environmental conditions prevailing at the time of sampling.

In case of other pipefish species, Gurkan and Taskavak[16] reported *b* of 2.42 and 3.54 for *Nerophis ophidion* and *Syngnathus acus* respectively, from Aegean Sea, Turkey. Ben Amor *et al.*[17] reported *b* of 2.62, 2.64, 1.836 and 5.476 respectively, for *Syngnathus abaster*, *S. acus*, *Syngnathus typhle* and *N. ophidion* inhabiting Tunisian waters. Khrystenko *et al.*[18] reported positive allometric growth pattern ($b > 3$; 3.017–3.338) in WLR of *S. abaster* populations in Dnieper river basin, Ukraine. Yildiz *et al.*[19] reported *b* of 3.41 for *S. acus* from Western Black Sea, Turkey. WLR of four pipefish species from Ria Formosa, SW Iberian coast, Portugal has been studied by Vieira *et al.*[20]. They reported *b* of 3.11, 3.36, 3.34 and 3.35 respectively, for *N. ophidian*, *S. abaster*, *S. acus* and *S. typhle* respectively. From the above studies, it can be deduced that the parameter *b* in WLR varies considerably with geographical location even for the same species. Several authors reported that WLR depends upon environmental factors (temperature, salinity), biological processes (season, food availability, habitats, gonad development, health) and also differences in the sizes of specimens subjected to WLR[18–24]. Thus, it appears that vast differences in WLRs and the parameter *b* between the present study and other studies could possibly be attributed to the combination of one or more of the above-mentioned factors.

According to Froese[23], when the parameter *b* which is the exponent of the arithmetic form of WLR is <3, then larger specimens of a species have changed their body shape to become more elongated. Similar observations have also been documented in streamline fishes which grow faster in body length than weight ($b < 3$)[24]. In the present study, estimated parameter *b* showed a strong negative allometric relationship implying that the weight increases at a slower rate than the body length in *S. biaculeatus*. This might be due to the unique morphology of *S. biaculeatus* and unfavourable environmental conditions. The increased degradation of habitat (seagrass) due to shrimp trawling, wind-driven country trawls, etc. along the PB and GoM regions[25,26] might have influenced the growth pattern in *S. biaculeatus*.

In the present study, the calculated Fulton's condition factor *K* for males (0.69 and 0.68 for PB and GoM respectively) of *S. biaculeatus* is relatively lower compared to females (1.08 and 0.84 for PB and GoM respectively) and juveniles (1.35 and 1.27 for PB and GoM respectively). The condition factor of fish is a quantitative indicative parameter of its well-being and reflects its growth and recent feeding conditions. Cakic *et al.*[15] reported *K* value of 0.34 ± 0.08 for *S. abaster* population from Danube river. Significant differences in *K* values for different maturity stages of males (immature, 0.37; mature, 0.39; egg-bearing, 0.38 and post-brooding, 0.39) and females (immature, 0.38 and mature, 0.40) in worm pipefish, *N. lumbriciformis* have been reported by Lyons and Dunne[27]. The index *K* is strongly influenced by both biotic and abiotic ecological conditions[27]. The *K* value in fish may vary according to the influences of physiological factors, gonad developmental status and food availability[28,29]. Male alligator pipefish are well known for their parental care of broods which are incubated in a specially developed open-type brood pouch at the ventral surface[11]. Energy used for developing brood pouch and nutrition of young ones might also affect growth pattern of male specimens.

In conclusion, *S. biaculeatus* could serve as a flagship species to evaluate the conservation value of seagrass beds[30]. The information provided in this study may improve our current understanding of *S. biaculeatus* populations inhabiting critical habitats. For better understanding of the ecology of *S. biaculeatus*, further studies delineating its growth pattern in spatial and temporal scales are required.

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Reasonable transition form of bridge–tunnel connecting section in mountainous expressway affected by crosswind

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In order to explore a reasonable transition form of mountainous expressway in bridge–tunnel connecting section, driver's dynamic behavioural changes affected by crosswind is analysed through driving simulator. The experimental section is composed of tunnel and bridge, with different width of left shoulder. Driver's dynamic behaviour consists of two main parts: counter steering wheel angle and heart rate. The results show that the influence on driver's dynamic behaviour is greater when the car encountered crosswind at the exit of the tunnel than the crosswind suddenly disappearing at entry of incoming tunnel. As design speed is 100 kmph, the recommended value of left shoulder width is 1.5 m for tunnel exit, while 1.75 m for entrance. For the facility of design and construction, the theoretical transition form of bridge–tunnel connecting section is simplified.

Keywords: Bridge–tunnel connecting section, cross wind, driving simulator, mountainous expressway, transition form.

BRIDGES and tunnels of mountain expressway occupy a large proportion and bridge–tunnel connecting section is prone to cause traffic accidents due to the special interfacing structure. The driver's visual and the state of psychology and physiology directly affect traffic safety; therefore, the analysis of the characteristics of traffic accident and factors affecting driving behaviour on these sections is important. Driving simulating experiment platform was established and the driver's heart rate index was used for safety evaluation of the bridge–tunnel connecting section in different driving speed in foggy weather[1]. The speed is a significant factor for traffic safety. Generally, the more the discrete form of speed distribution, the higher is the accident rate[2]. According to accident data, more than half of the accidents on expressway occurred in bad weather. As for bridge–tunnel connecting section of mountainous area, fog, snow, rain, frost and crosswind were the most influential weather factors[3]. Bridge is often located in deep valley where crosswind blows. If vehicles were blown by strong crosswind while driving, the tyres would deviate transversely and lead to vehicle off-tracking or even sideslipping. The analysis theory of vehicle–bridge coupling vibration with the action of a crosswind load was built[4]. Driving safety problems on a bridge deck in a strong crosswind environment by considering the influence of driver behaviour was also studied[5]. Due to the different size and weight of car and truck, different vehicles affected by bridge deck crosswind have different sensitivity. Two-side clear distance of bridge–tunnel connecting section will cause different psychological reactions from the driver. Reasonable shoulder width could improve the driver's speed and direction control ability, which is an advantage to traffic safety[6]. Bus driver's mental workload in response to the narrow shoulder width and the need to anticipate traffic hazards was a significant concern both for operational and driver safety[7]. The front view is different from general road environment in bridge–tunnel connecting section. There is no study yet on the driver's reaction with different shoulder widths.

In the mountain expressway, the lateral clearance is defined as the clear distance between fence and lane line. The lateral clearance is an important parameter in the design of the expressway. It has important influence on the comfort of the expressway driving safety. The distance

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