Morphometric relationship and the spawning season of *Acetes intermedius* from the coast of Miri Sarawak, Northwestern Borneo

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Abstract. The present study describes the morphometric (length, L-weight, W) relationship ($W = aL^b$) and determined the spawning season of *Acetes intermedius* sampled from the coastal waters of Miri, Sarawak from March 2016 until February 2017. Morphometric measurements for individual shrimp (total length, TL and body weight, BW) were recorded and length-weight relationships were estimated using FiSAT program. The TL range from 15.97 to 40.45 mm and 12.95 to 42.05 mm for males and females *Acetes* respectively. The average male to female shrimp sex ratio was 1:4.13. The length-weight relationships were given by $W = 0.0001869L^{1.9232}$ or Log TW = 1.9232 Log TL – 3.7285, $r^2 = 0.75$ for both sexes, $W = 0.0001685L^{1.9578}$ or Log TW = 1.9578 Log TL – 3.7733, $r^2 = 0.76$ for female and $W = 0.01314L^{0.6224}$ or Log TW = 0.6224 Log TL – 1.8813, $r^2 = 0.75$ for male. The asymptotic length (L_∞) was estimated at 43.20 mm, while the growth co-efficient (K) was 1.20 yr^{-1}. Total mortality (Z) was estimated at 3.39 yr^{-1}, the natural mortality (M) was calculated as 1.88 yr^{-1} and fishing mortality (F) was 1.51 yr^{-1}. The maturity and spawning season of *A. intermedius* were determined through ovary examination. The female attained first sexual maturity at a size of 26 mm total length. The matured and near to spawn stages (stage II and III) occurred throughout the year, but > 50% of spawning stages were occurred in June and September. It can be inferred that *A. intermedius* spawns toward the middle of the year from June onwards in the coastal waters of Miri, Sarawak. As a conclusion, the research was important for the *Acetes* fishery management in the future for a sustainable exploitation of the resource that will bring about a positive impact to the economy of Miri traditional fishermen.

Key Words: *Acetes intermedius*, FiSAT, ovary examination, spawning season, fishery management.

Introduction. *Acetes* is a planktonic shrimp, locally known as '*Udang Geragau*' in Malacca, '*Udang Baring*' in Terengganu and '*Bubok*' in Sarawak. *Acetes* contribute to the major productivity of the ocean. It is among the zooplankton genera, which is commonly exploited and served as a major nourishment of protein to the coastal area populations. *Acetes* is characterised by a total length approximately between 10 and 40 mm (Omori 1975; Arshad et al 2008). Recently, 14 species of *Acetes* have been recognised and distributed worldwide (Wong et al 2015).

In Malaysia, the species *Acetes intermedius* is found in the west coast of Peninsular Malaysia, from Perlis to Johor, the shallow coastal waters of Malacca (Arshad et al 2007) and in Bintulu, Sarawak (Saini et al 2011; Amin et al 2008). For the year 2014, Sarawak has landed a substantial amount of *Acetes* spp. at 3,740 tonnes, 9.42% of the national output (Department of Fisheries Malaysia 2014) and has become a commercially important resource in the state for many years. *Acetes* is a seasonal fishery, in which the shrimps conspicuously aggregate near the shore in certain months and are mainly fished with estuarine pushnet, scoopnet, scoop-seine net and small purse-seine net in Miri, Sarawak.

However, at present, the *Acetes* fishery information remain scarce in Sarawak. Previous studies in Sarawak were only conducted by Saini et al (2011) and Amin et al (2008), focusing on the growth, mortality and stock recruitment, and the population structure, length-weight and length-length relationship of *Acetes intermedius* respectively. Furthermore, *Acetes* fishery in Sarawak is not fully regulated and has become an open access fishery for the past few years during the seasonal abundance of *Acetes* that could lead to overexploitation. Hence, it is crucial to initiate a management plan to determine the spawning season through biological research and the stock of *Acetes* by the understanding of the growth and population parameters via FAO-ICLARM Stock Assessment Tools II (FiSAT II).

FiSAT II is a software program validated by the Food and Agriculture Organisation (FAO), consisting of methodologies for the analysis of stock to facilitate in the management options for fisheries (Gayanilo et al 2005). In this study, FiSAT II was used for the determination of the length-weight relationships (LWRs), which has become a vital aspect in fishery management, as the length data is used to estimate the weight or biomass, to obtain the indices of condition (Anderson & Neumann 1996; Jobling 2002), and to establish the growth parameters of *A. intermedius*. The data from this study is important to facilitate the conservation and management for the future of *Acetes* fishery in Miri, Sarawak.

Material and Method

Study location and sample collection. Samples were collected from March 2016 until February 2017 in the coastal waters (below 12 NM) of Miri depicted in Figure 1.

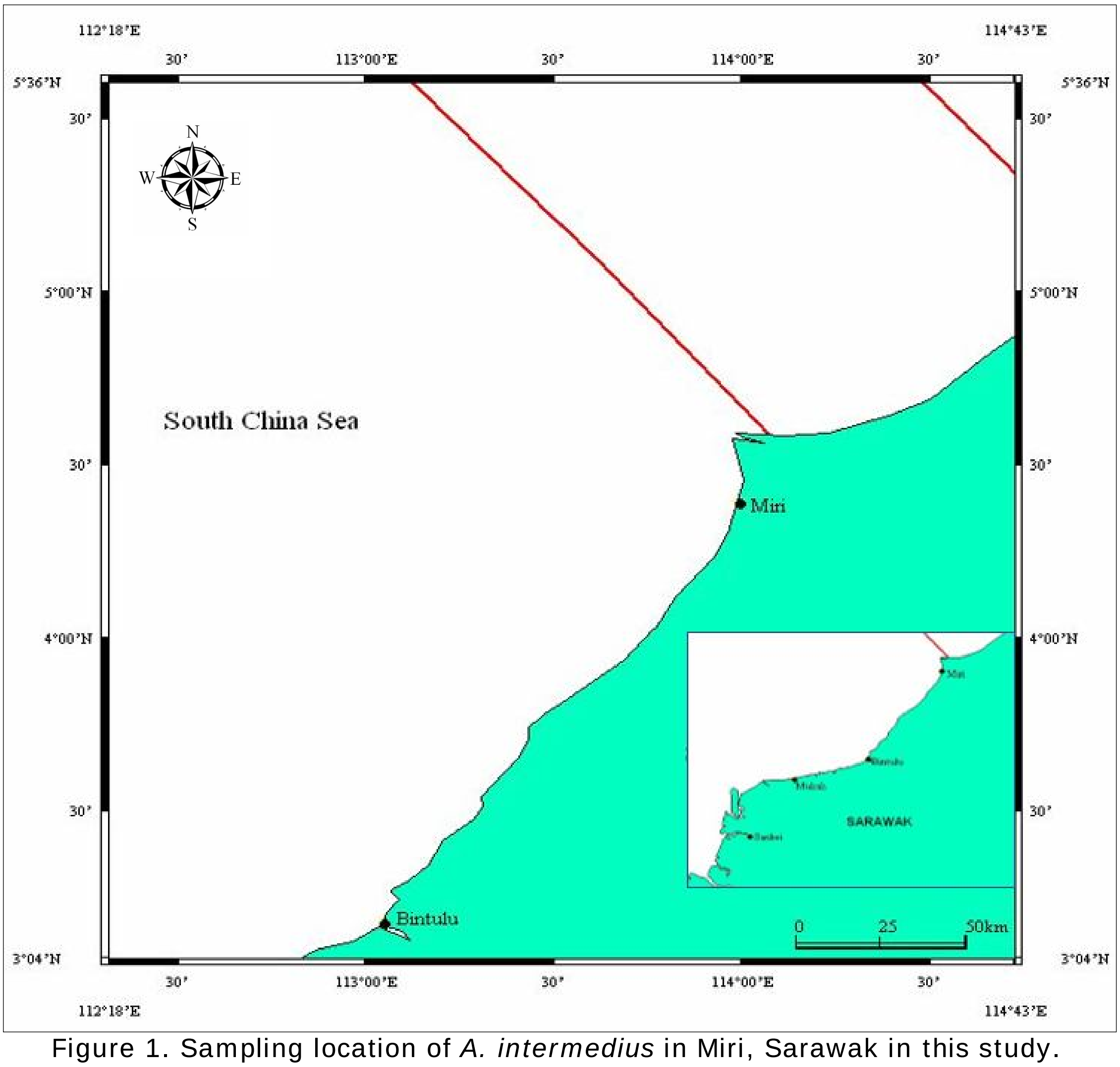

Figure 1. Sampling location of *A. intermedius* in Miri, Sarawak in this study.

Sample preservation. The fresh samples were placed in a bottle and fixed with 10% buffered formalin as described by Oh et al (2010) and Amin et al (2010). Then, the samples were labeled and transported to the laboratory for further analysis.

Sex ratio. In the laboratory, 200-300 individuals from the preserved samples were taken randomly each month and identified according to its morphometric characteristics for males and females under a dissecting microscope (Olympus SZ61TR, Japan) as described by Omori (1975). The key differentiation is the presence of petasma and the clasping spine of the lower antennular flagellum in males.

Length-weight measurements and FiSAT analysis. Randomly 200-300 individuals were selected from the preserved samples and subjected to length-weight measurements. The total length was measured (±0.1 mm) using a dissecting microscope (Olympus SZ61TR, Japan), along the dorsal from the tip of the rostrum until the tip of the telson. Body weight was measured at 0.1 mg accuracy by using an electronic balance (Mettler Toledo ME 204).

Length-weight relationship. This was analysed using FiSAT computer program using the relationship of Quinn & Deriso (1999) and Ricker (1975). The calculation is given below:

$$W = aL^b$$

where: W = weight (mg);
a = intercept (condition factor);
L = total length (mm);
b = slope (growth coefficient, i.e., *Acetes* relative growth rate).

Then, the parameters ‘a’ and ‘b’ were estimated:

$$\log_{10} W = \log_{10} a + b \log_{10} L$$

The r^2 value estimated indicates the quality of the linear regression. The 95% confidence limits of the parameters ‘a’ and ‘b’ and the statistical significance level of r^2 were estimated.

Monthly length-frequency distributions. In FiSAT, the frequency data was arranged prior to the determination of asymptotic length (L_∞), growth co-efficient (K) using ELEFAN-I (Pauly & David 1981). The response surface was initially performed to estimate the possible L_∞ and K by referring to the Rn values to obtain the best combination of growth parameters. Subsequently, K scan was conducted to obtain the value of K. The L_∞ and K were then used to calculate the growth performance index (Φ’) in FiSAT:

$$\Phi' = 2 \log_{10} L_\infty + \log_{10} K$$

where: Φ’ = growth performance index;
L_∞ = asymptotic length;
K = growth coefficient.

Potential longevity (t_{max}). Using the K estimated, potential longevity was calculated according to Pauly's formula in FiSAT as shown in Salarpouri et al (2018):

$$t_{max} = 3/K$$

Total mortality coefficient (Z) and natural mortality (M). The Length Converted Catch Curve was used to estimate total mortality. Then, the natural mortality rate (M) was estimated (Pauly 1980):

$$\text{Log}_{10}M = -0.0066 - 0.279\text{Log}_{10}L_\infty + 0.6543\text{Log}_{10}K + 0.4634\text{Log}_{10}T$$

where: M = natural mortality;
L_∞ = asymptotic length;
K = growth co-efficient of the VBGF;
T = mean habitat water temperature (°C) annually.

Fishing mortality (F). Fishing mortality (F) was then calculated using the relationship:

$$F = Z – M$$

where: F = fishing mortality;
M = natural mortality;
Z = total mortality.

Exploitation level (E). The exploitation level (E) was calculated with an equation described by Gulland (1971) as depicted in Agustina et al (2018) and Panhwar et al (2018):

$$E = F/Z = F/(F+M)$$

Length-frequency distributions. According to Bhattacharya's method in FiSAT (Gayanilo et al 2005), the polymodal length-frequency distributions was obtained. The size or age groups identified were derived from three consecutive points and the results selection was based on the value of the standard deviation (SD) (Gayanilo et al 1989), separation index (SI) and the number of identified age groups.

Relative yield-per-recruit (Y/R) and relative biomass-per-recruit (B/R). This was performed in FiSAT according to the Beverton and Holt model (Beverton & Holt 1966), as modified by Pauly & Soriano (1986). The parameters required were L_C/L_∞ and M/K. From the analysis, the E_{max} (maximum allowable limit of exploitation), the $E_{0.1}$ (the exploitation rate at which the marginal increase in relative yield-per-recruit is 10% of its value at E=0) and $E_{0.5}$ (the exploitation rate corresponding to 50% of the unexploited relative biomass-per-recruit) were estimated.

Reproductive biology analyses

Ovary examination. The females were examined monthly for gonadosomatic index (GSI) estimation. Initially, body weight was measured (±0.1 mg). The females were dissected under a compound microscope to investigate the ovaries. The dissection was done using fine needles and the ovaries were taken out immediately and preserved in 5% formalin in a labeled vial and stored for examination. The ovaries weight was recorded to the nearest ±0.1 mg with an electronic digital balance. The ovaries maturity was classified into four categories based on its morphological characteristics according to Wu & Cheng (1957):

- stage I: immature ovaries. Eggs are small (23.0-82.8 µm in diameter). The ovary shape like a ribbon with the developing anterior lobes in the larger ones. Spermatophores are not present in the thelycum;
- stage II: mature ovaries. The eggs sizes are varying, ranges at 64-161 µm in diameter, with the present of small sizes eggs as above (Stage I). The ovary size increases, laterally expanded at the dorsal side of the first and second abdominal somites with the development of wavy margins around the lobes. Spermatophores are present for certain individuals;
- stage III: near-spawning ovaries. The eggs are neatly arranged with diameter 82.8-207 µm. The ovary has green or brown in colour;
- stage IV: spent ovaries. No presence of mature eggs or completely empty or a few eggs in the ovary. In some individuals, large amount of small eggs presents near the blood vessels in the middle of the ovary.

The GSI will be estimated as follows (Oh & Jeong 2003):

$$GSI = \frac{\text{Ovary wet weight}}{\text{Female body wet weight}} \times 100$$

Fecundity. Female *Acetes* of 40 individuals, which were in their mature or near-spawning stages were used to estimate fecundity. The ovary was preserved after dissected at 3 positions (fore, middle, and rear). The mature oocytes (1/3 selected part) was weighed to the nearest 0.01 mg and recorded. A drop of water on the concave glass slides and fine needles were required to help manipulating the ovary and covered with a cover slip. Then, the oocytes were examined under a compound microscope, counted, measured the diameter and recorded. Fecundity of each individual was estimated as follows (Kodama et al 2004; Amin et al 2009b):

$$F = F_s \times \frac{GW}{GW_S}$$

where: F = estimated fecundity of an individual;
F_s = number of oocytes in a sample;
GW = total weight of the ovary;
GW_s = weight of the sample of the ovary.

The mean of the estimated fecundity for each individual was assumed as that individual's fecundity.

Size at sexual maturity. The percentage of occurrences of females at each ovarian maturity stage according to total length classes was examined using the year-round samples (Amin et al 2010).

Results

Sex identification. The *A. intermedius* were both identified for their sexes according to the key indicators specified by Omori (1975). In males, the presence of petasma with pars astringens with 5 hooks, possess 1 clasping spine (13-14 segments) at the lower antennular flagellum with 12-15 segments and the apex of telson with triangular-pointed shape. For the females, the apex of telson was round-shaped and had blunt projection of basis at the third legs.

Sex ratio. In the total of 2200 *A. intermedius* examined, the males were counted at 429, while females were 1,771. The results hence indicated that the overall sex ratio was 1:4.13, in which the total number of females were higher throughout the monthly samples from March 2016 until February 2017. The sex ratio by total length showed that the females were predominance of larger class (42.50 mm) as there were no males observed for total length more than 40 mm (Figure 2).

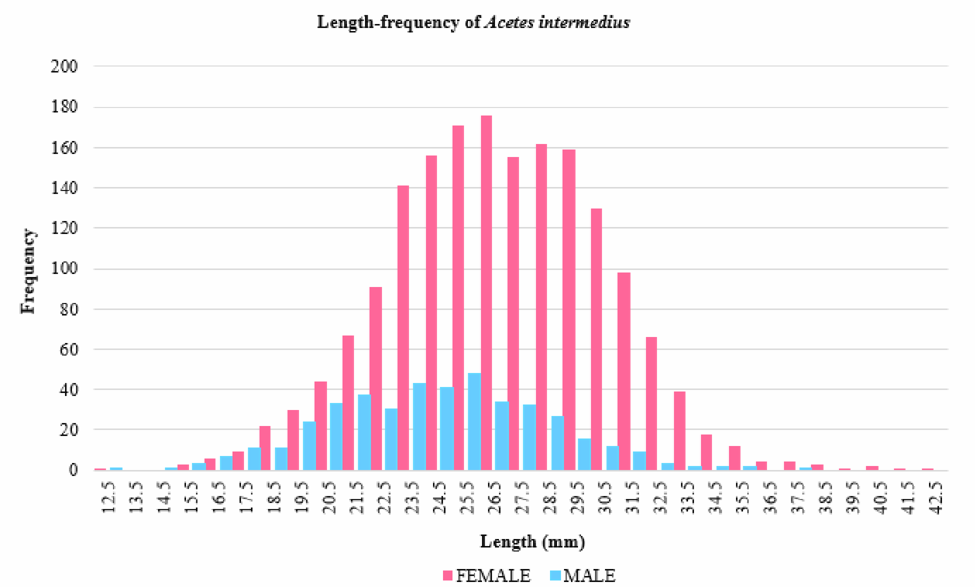

Figure 2. Length frequency of *A. intermedius* in Miri.

FiSAT results

Length-weight relationship. The regression between the total length (TL) and total body weight (TW) relationship for *A. intermedius* (both sexes, males and females) were shown in Figure 3.

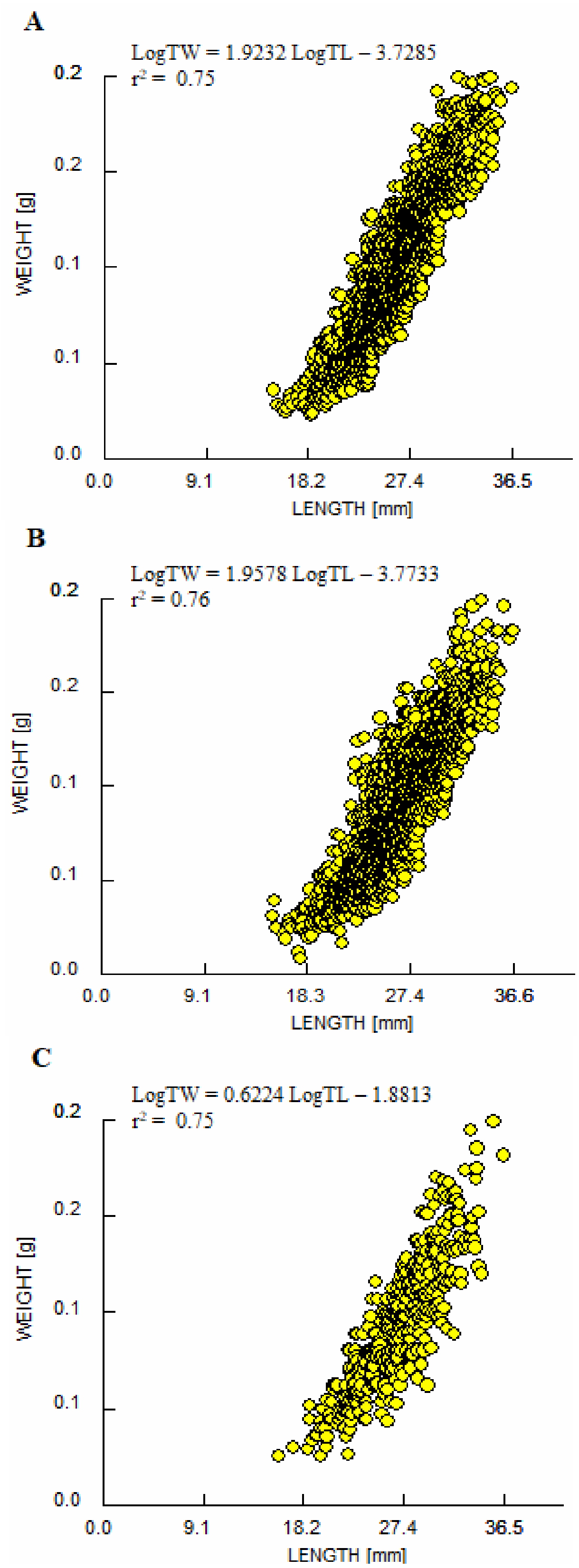

Figure 3. Regression analysis of *Acetes intermedius* via FiSAT. A: both sexes; B: female; C: male.

Growth parameters. The observed and the predicted extreme length (L_{max}) were found to be 42.50 mm and 41.06 mm (Figure 4). The range at 95% confidence interval for extreme length was calculated as 38.80-43.33 mm. The estimated L_∞ and K value were 43.20 mm and 1.20 yr^{-1} (Table 1) with the Rn value of 0.128. The optimized growth curve was superimposed on the restructured length-frequency histograms (Figure 5).

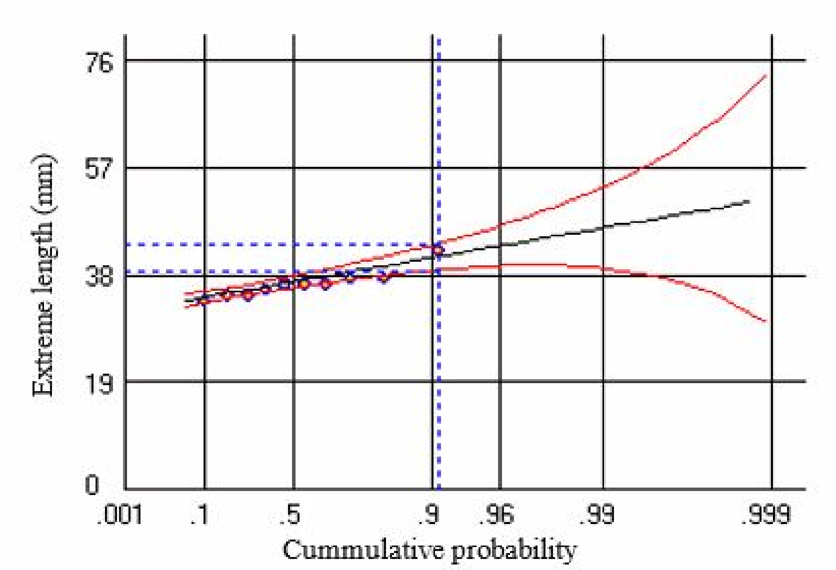

Figure 4. Predicted maximum length according to extreme value theory (Formacion et al 1991).

Table 1

The value of parameters obtained from FiSAT analysis

Parameters	*Value*
L_∞	43.20 mm
K	1.20 yr^{-1}
Z	3.39 yr^{-1}
M	1.88 yr^{-1}
F	1.51 yr^{-1}
t_{max}	2.5 yr^{-1}
Φ′	3.35 yr^{-1}
E	0.45
E_{max}	0.73
$E_{0.1}$	0.61
$E_{0.5}$	0.36
L_{50}/L_C	21.74 mm
L_{75}	22.61 mm

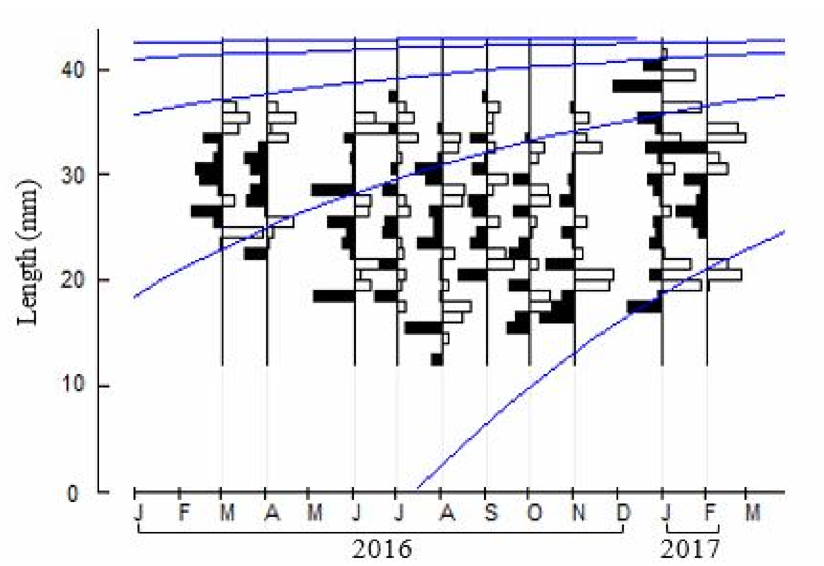

Figure 5. Von Bertalanffy growth curves of *A. intermedius* superimposed on the restructured length-frequency histograms. The black and white bars indicated positive and negative deviation respectively from the “weighted” moving mean of three length classes and they represented pseudo-cohorts.

Mortality and exploitation rate. Total mortality coefficient (Z) was estimated as 3.39 yr^{-1} using the length converted catch curve. Natural mortality (M) was estimated at 1.88 yr^{-1}. Based on the Z obtained, the fishing mortality (F) was found to be 1.51 yr^{-1}. From these figures, an exploitation rate (E) was calculated at 0.45 for the *A. intermedius* in Miri waters. The potential longevity (t_{max}) for *A. intermedius* was 2.5 yr^{-1}, while the growth performance index was 3.35 yr^{-1}.

Length at first capture. The length of the *Acetes* initially captured (approximately 50% of the *Acetes* becomes susceptible to the gear) was calculated from the probability of capture analysis. The value obtained was $L_{50\%}$ (length at first capture, L_c) = 21.74 mm and $L_{75\%}$ = 22.61 mm (approximately 75% of the *Acetes* was caught in the gear).

Age groups. The Bhattacharya's method in FiSAT had determined that the modal length of the *A. intermedius* was ranging from 15.50 mm (23.12 mm in October) to 42.05 mm (36.01 mm in January). The monthly frequency distributions suggested that the population consists of 2 major age groups with the range of 23 mm and ≥ 36 mm total length (Figure 6).

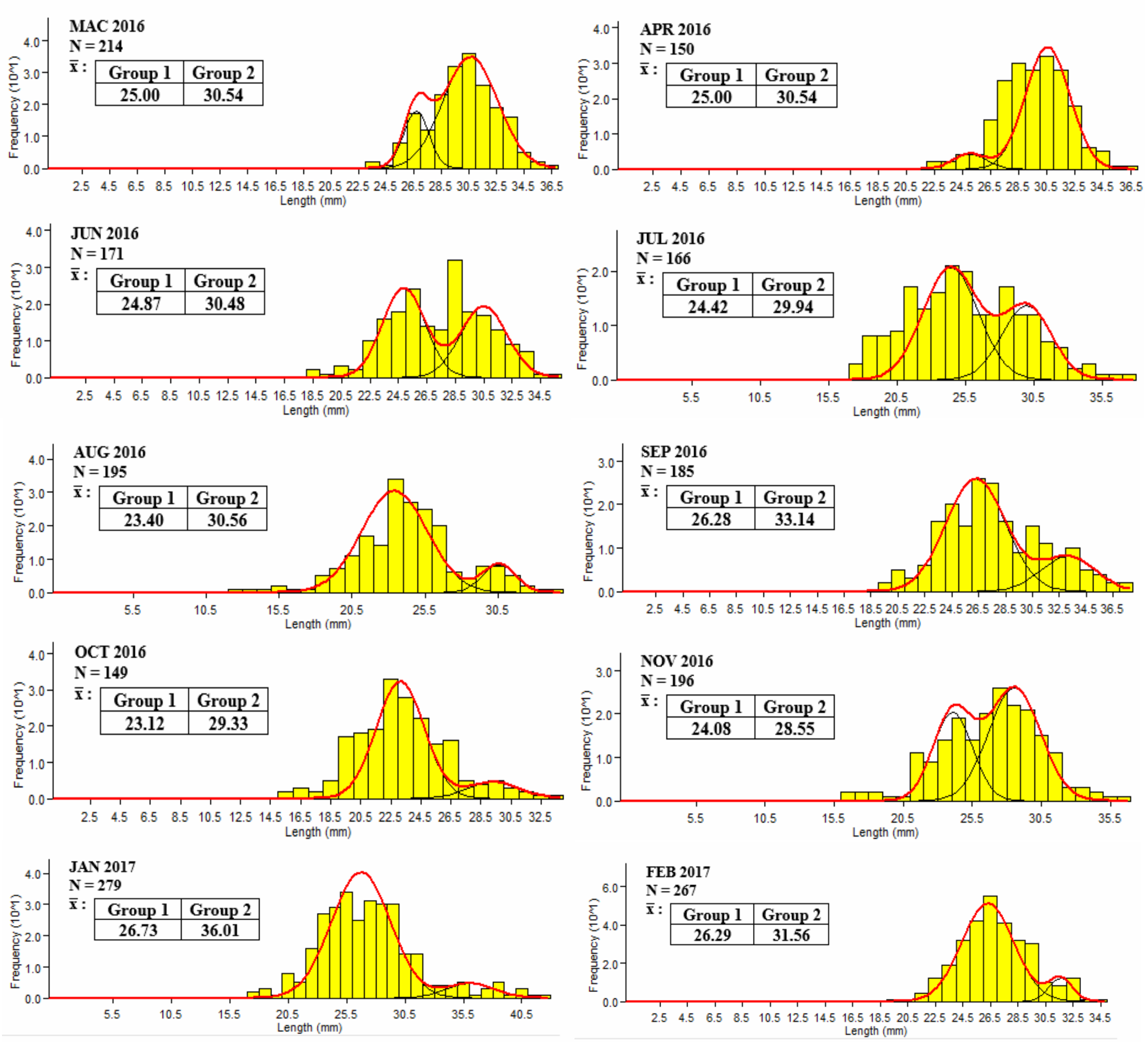

Figure 6. Monthly length-frequency distributions of *A. intermedius*.

Relative yield per recruit and biomass per recruit. Exploitation level was calculated as 0.45 during the length converted catch curve analysis and shows that the *A. intermedius* fishery in the coastal waters of Miri is not over exploited. The value of L_c/L_∞ = 0.503; M/K = 1.567 were calculated earlier. The maximum allowable limit of exploitation level (E_{max})

was estimated at 0.73. The $E_{0.1}$ and $E_{0.5}$ were computed at 0.61 and 0.36 respectively (Figure 7).

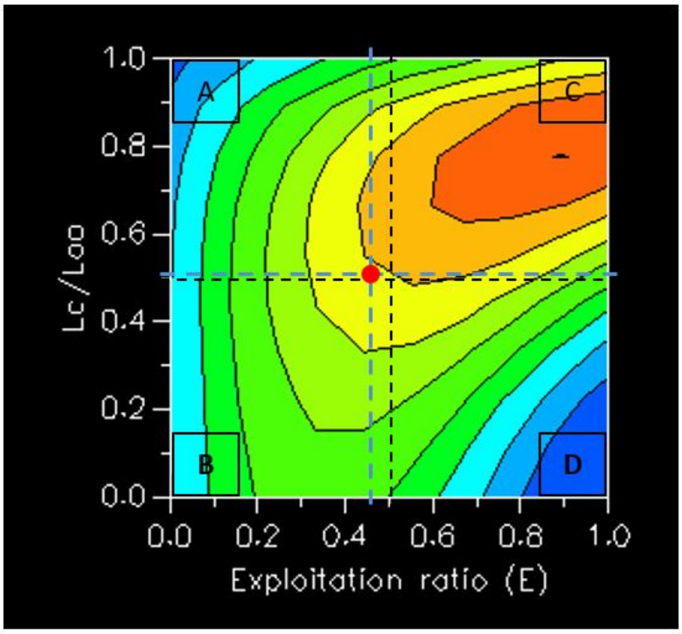

Figure 7. Relative Y/R and B/R of *A. intermedius* using the Beverton and Holt analysis (knife-edge method). Blue line represents the L_c/L_∞ = 0.503 and E = 0.45; the red dot represents the intersection of L_c/L_∞ and E, indicated the fishing regime for *A. intermedius* lied in Quadrant A.

Biological study results

Spawning season. Changes in the mean GSI and its maturity stages for females every month was presented in Figure 8. The mean GSI of females increased from March and reached its peak in June and September 2016. The GSI value was at a lower level in October until January 2017. The maximum value (GSI = 2.41) was observed in September, where most females were found in matured stage, and the minimum (GSI = 0.26) was observed in October, where most females were found to be in immature phase or spent. The GSI showed 2 obvious peaks in the months of June and September.

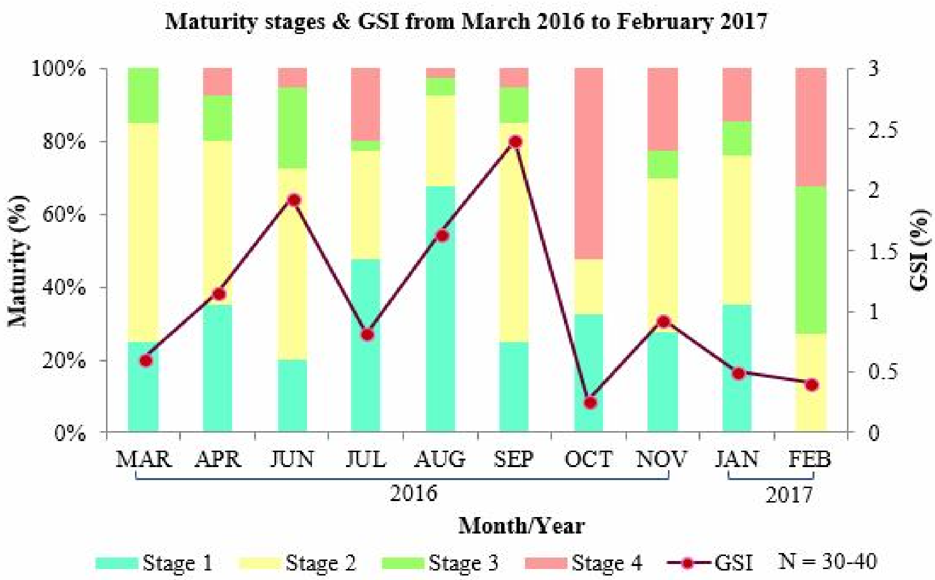

Figure 8. Variations in the GSI of female *A. intermedius* and the percentage of occurrence of the ovarian maturity stages for a year-round sample from March 2017 to February 2017.

All of the stages occur every month from April until September, in November and in January. Stage I recorded the lowest value in June and September, when their mean GSI were at the peak, indicated by the high value. The mature and near-spawning stages (stage II and stage III) accounts for > 50% in June and September. These indicate that the spawning of *A. intermedius* occurred during the months of June and September.

Size/length at first maturity. The length at sexual maturity was determined by examining the percentage composition of females for each ovarian maturity stages against the total length classes (Figure 9). The maturity (stages II and III) first occurred at > 50% for total length of 26 mm, which indicated that the size at sexual maturity of the female *A. intermedius* was at 26 mm of total length.

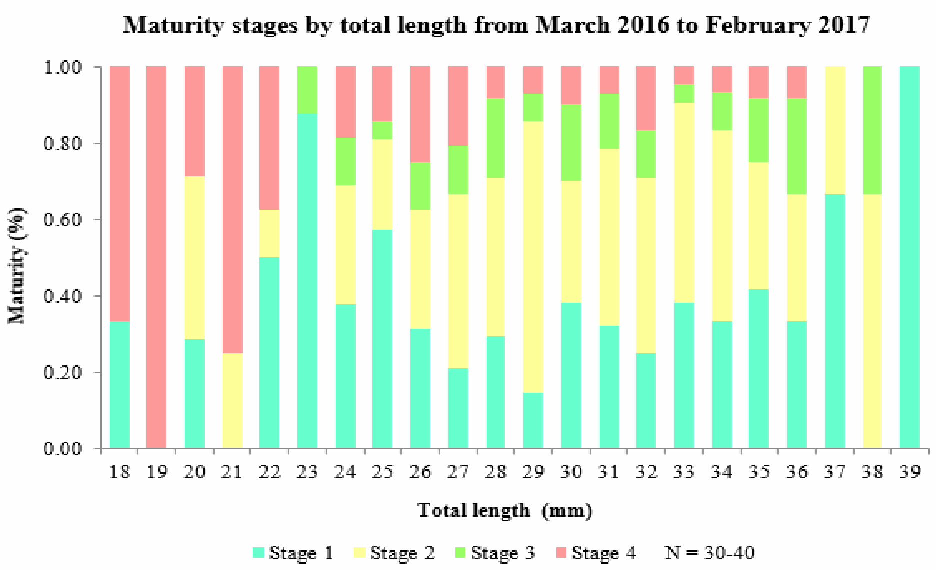

Figure 9. The percentage of occurrence of the ovarian maturity stages according to total length.

Fecundity. The highest mean fecundity was recorded in June 2016 and February 2017 with 691.35 (±7957 eggs) and 592.95 (±6173 eggs) respectively (Figure 10). Individual fecundity was ranged at 40-2166 eggs with sizes ranging from 20.21 mm until 38.00 mm (Table 2).

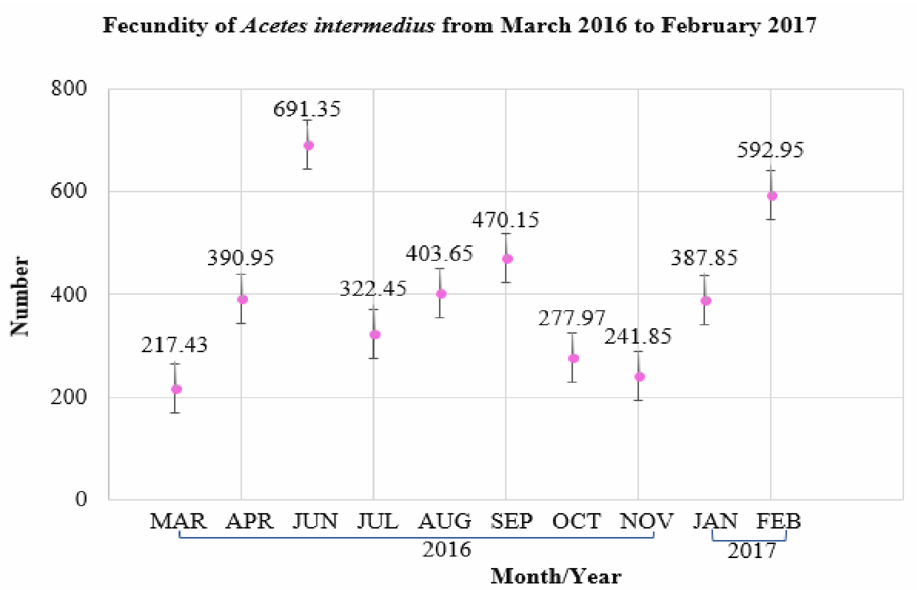

Figure 10. Fecundity of *Acetes intermedius* from March 2016 until February 2017.

Table 2

Fecundity of *A. intermedius* in Miri

	TL	*BW*	*GW*	*Fecundity (no. of eggs)*
Mean	30.01	150.81	2.07	449.3686
SD	3.75	37.07	1.57	380.3433
Range	20.21-38.00	60-237	0.2-6.9	40-2166

Discussion. The sex ratio calculated was important in case of artificial spawning, where the appropriate numbers of male and female should be initially known. According to Xiao and Greenwood (1993), the sex ratio should be 1:1 (males:females) in nature, but present sex ratio for *A. intermedius* in Miri was 1:4.13, which the amount of females was quadruple the amount of males. Similarities occurred in the studies conducted by Arshad et al (2007), Arshad et al (2008), Amin et al (2009b), and Wong et al (2017), where the number of females were higher than the males. In addition, this was supported by studies done by Zhong et al (2001) and Oh & Jeong (2003), whereby the dominant sex in the Laizhou Bay, Huanghe estuary and coastal areas of Korea respectively were of female *Acetes*. The factors affecting the ratio could be due to the faster growth of females causing it to be the dominant catch (Oh & Jeong 2003), temperature and food availability (Luo & Zhang 1957), and mortality differences between sexes and migration (Kim 2005). In another study by Chiou et al (2003) in southwestern Taiwan reported that the migration pattern of *A. intermedius* affected the sex ratio. The *Acetes* were vertically migrated during the summer from estuaries to coastal waters and moved horizontally to the surface during night and migrated to deeper water during the day. Hence, this study also suggested that the skewed ratio of *A. intermedius* in Miri might be related to size differences, habitat preferences by different sexes, temperature, food availability and migration pattern according to environmental temperature.

The value of ‘b’ is stated as isometric when b = 3. The value of ‘b’ in this study were 1.9232, 0.6224 and 1.9578 for both sexes, males and females respectively. The values were lower than the isometric value (b = 3) which indicates negative allometric. Previous studies revealed that the values of ‘b’ showed considerable variation in different location and different species around the world (Table 3). The three coefficient of determination (r^2) in the length-weight relationship (Figure 3) showed that $r^2 \geq 0.75$. This suggested that the total length increase as the weight is heavier for *A. intermedius*. The estimated L_∞ and K value in this study were 43.20 mm and 1.20 yr^{-1} respectively. The growth parameters were compared with previous studies (Table 4). Difference in the population parameters was agreed with different genus and in different areas of the world. The highest value of L_∞ was recorded in this study, while the highest K was recorded in Bintulu at 1.90 yr^{-1} for *A. intermedius* (Saini et al 2011). The same species occurred in Malacca recorded at 34.65 mm for L_∞ and 1.50 yr^{-1} for K (Arshad et al 2007). The lowest L_∞ value appeared in Bangladesh for *A. indicus* was 31.00 mm (Zafar et al 1997), while the lowest K value was in Korea for female *A. indicus*, 0.69 yr^{-1} (Oh & Jeong 2003).

Table 3

Parameters of length-weight relationship (a and b) for different *Acetes* genus in various location

Location	*Species*	*a*	*b*	*Growth type*	*Source*
Miri	*A. intermedius*	0.000187	1.923	(-) Allometric	Present study
Bintulu	*A. intermedius* (F)	0.0033	3.044	(+) Allometric	Amin et al (2008)
Bintulu	*A. intermedius* (M)	0.0025	3.148	(+) Allometric	Amin et al (2008)
Malacca	*A. intermedius*	0.021	3.249	(+) Allometric	Arshad et al (2007)
Malacca	*A. japonicus*	0.004	3.063	(+) Allometric	Amin et al (2009a)
Malacca	*A. indicus*	0.0014	3.411	(+) Allometric	Amin et al (2009a)
China	*A. japonicus*	0.130	2.155	(-) Allometric	Lei (1988)
Japan	*A. sibogae*	0.0085	2.985	Isometric	Ikeda & Raymont (1989)

Table 4
Growth parameters and the computed growth performance index (Φ′) of different *Acetes* genus in various tropical conditions

Location	*Species*	*L_∞ (mm)*	*K (yr^{-1})*	*Φ′ (yr^{-1})*	*Z (yr^{-1})*	*E*	*Source*
Malaysia (Miri)	*A. intermedius*	43.20 TL	1.20	3.35	3.39	0.45	Present study
Malaysia (Bintulu)	*A. intermedius*	43.05 TL	1.90	3.56	4.69	0.47	Saini et al (2011)
Malaysia (Malacca)	*A. intermedius*	34.65 TL	1.50	3.26	-	-	Arshad et al (2007)
Malaysia (Malacca)	*A. japonicus*	29.08 TL	1.40	3.07	5.16	0.54	Amin et al (2009a)
Bangladesh	*A. indicus*	31.00 TL	1.70	3.22	6.07	0.22	Zafar et al (1997)
Bangladesh	*A. erythraeus*	37.00 TL	1.20	3.21	4.72	0.24	Zafar & Amin (2002)
Korea	*A. chinensis* (F)	13.51 CL	0.69	2.10	3.93	-	Oh & Jeong (2003)
Korea	*A. chinensis* (M)	10.48 CL	0.84	1.97			Oh & Jeong (2003)

The value of growth performance index in this study was 3.35 yr^{-1}. The largest was from the study done by Saini et al (2011) with 3.556 yr^{-1} while the lowest was from the study by Arshad et al (2007) with 3.255 yr^{-1} for the same species.

Total mortality (Z) estimated at 3.39 yr^{-1} was lower than the study recorded in Bintulu with 4.689 yr^{-1} for *A. intermedius* (Saini et al 2011). The estimated value of longevity, t_{max} was 2.5 yr^{-1}, was higher compared to the previous study in Bintulu (Saini et al 2011). Higher natural mortality (1.88 yr^{-1}) verses fishing mortality (1.51 yr^{-1}) reflected the unbalanced position of the stock in recent study. The exploitation rate (E) was 0.45, which was slightly lower than the optimum level of exploitation (E = 0.50), indicated that the fishery of *A. intermedius* in Miri was not overexploited.

The computation of relative yield-per-recruit and relative biomass-per-recruit showed that the exploitation rate (E = 0.45) was below the conservative yield concept ($E_{0.1}$ = 0.61) suggested that the *Acetes* fishery currently is not excessive. Pauly & Soriano (1986) model showed that the yield isopleths could be divided into four quadrants based on the critical size ratio, L_c/L_∞ (a proxy to mesh size) and current exploitation ratio, E (a proxy to effort). Quadrant A (L_c/L_∞ = 0.5-1; E = 0-0.5) represents underfishing, Quadrant B (L_c/L_∞ = 0-0.5; E = 0-0.5) represents eumetric fishing, Quadrant C (L_c/L_∞ = 0.5-1; E = 0.5-1) represents developed fishery and Quadrant D (L_c/L_∞ = 0-0.5; E = 0.5-1) represents overfishing. The yield isopleths for this study (L_c/L_∞ = 0.503 and E = 0.45) belongs to the Quadrant A. This suggested that the fishing regime of *A. intermedius* in Miri waters was underfishing and large *Acetes* were caught at a low effort, therefore the effort should be increased strongly or remain.

The spawning activities were further confirmed by determining the monthly changes in GSI. The results suggested that the major spawning months for *A. intermedius* were in June and September (Figure 8). According to Amin et al (2010), the spawning behavior of *Acetes* was related to water temperature as highest spawning normally occur in the warmer months.

The sexual maturity of *A. intermedius* first occurred at the length of 26 mm. Previous studies by Amin et al (2009b; 2010) were recorded for different species (*A. indicus* and *A. japonicus*) at 23 mm and 17.5 mm respectively. It was also found that the length at first capture of 75% (L_{75} = 22.61 mm) was smaller than the length at first maturity (26 mm) revealed the harvesting of pre-spawning *Acetes*. This might cause a greater reduction of the catch in the future. It is important to allow the *Acetes* to reproduce at least once in a lifetime to replenish the stock so that the population can be maintained equilibrium. Hence, the length at first capture should be larger than the length at first maturity (Narges et al 2011).

The mean fecundity of *A. intermedius* was 449.3686 eggs with the maximum and minimum values of fecundity were 2166 and 40 eggs respectively. There was no published data regarding fecundity of *A. intermedius* recently, therefore no comparison could be performed.

Conclusions. The asymptotic length (L_∞) of *A. intermedius* was 43.20 mm with growth coefficient K was 1.20 yr^{-1}. Fishing mortality, total mortality and natural mortality was computed as 1.51 yr^{-1}, 3.39 yr^{-1} and 1.88 yr^{-1} respectively. The exploitation level was 0.45, slightly under the optimum exploitation level (E = 0.5) and the fishing regime was categorised as underfishing. The results indicated that the current management is satisfactory and there is unnecessary to warn for any intervention, or in the other hand, the management could introduce a plan to increase the fishing effort reasonably to obtain more yields without leading to over exploitation. However, the *Acetes* fishery in Sarawak waters might be risk of over-capitalization (over exploitation) as it is an open access fishery, hence the fishing effort should be stabilized.

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