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Landings of *Acetes* spp. in the east coast of Sabah in the past 30 years (1990-2019)

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Abstract. The genus *Acetes* is a minor planktonic crustacean group, known by locals as '*Udang Geragau*', '*Udang Baring*' or '*Bubok*' in different parts of Malaysia. The main objective of this research is to study the impact of climatic events on *Acetes* spp. landings at the East Coast of Sabah waters (Kudat and Tawau) in the past 30 years (1990-2019). Landing data on *Acetes* was obtained from the Fisheries Department of Sabah, Malaysia while the climatic data were provided by Malaysian Meteorological Department. One-way ANOVA analyses were conducted on the mean temperature, relative humidity, rainfall and the annual landings of *Acetes* spp. Pearson's correlation test was later performed to measure relationship between the annual *Acetes* spp. landings and the variables as mentioned above. The results of correlation tests revealed that two variables (mean temperature and relative humidity) were having weak negative correlations with the annual landings in Kudat. Mean annual rainfall showed weak positive correlation with the *Acetes* landings in Tawau. The present study showed that changes in climatic event does influence the annual landings of *Acetes* spp. in the East Coast of Sabah.

1. Introduction

According to Omori (1975) [1], there are 20 species of *Acetes* that have been reported globally, and among them some have been considered to be synonymous. Recently, there are 14 species of *Acetes* that have been acknowledged and distributed around the world [2]. According to Xiao & Greenwood (1992) [3], *Acetes* live in estuaries and coastal waters in tropical, subtropical, and temperate regions around the world. Ten out of 14 known species can be found in the Indo-West Pacific, and the region rich in species is the Indo-Malay Archipelago region where the latitudinal range is between 41°N and 34°S [1]. However, only 8 out of 14 species of *Acetes* are found in Malaysian waters. This includes *Acetes indicus*, *Acetes japonicus*, *Acetes serrulatus*, *Acetes vulgaris*, *Acetes johni*, *Acetes sibogae*, *Acetes intermedius* and *Acetes erythraeus* [4, 5, 6, 7].

The genus *Acetes* is a minor planktonic crustacean group that plays a crucial role in the marine food webs. It feeds on various food item ranging from diatoms, copepods, and larvae of decapods to detritus, and simultaneously serves as main food source for many other predators, including ctenophores, cephalopods, crustacean, fish and juvenile fishes [8, 9]. Besides maintaining a balanced ecosystem,



Acetes is equally important for commercial in Malaysia [10]. Other than being used as food organism for aquaculture industries, it is also consumed by humans and domestic animals. Only a small part of the *Acetes* catch is marketed as fresh shrimps, while the larger proportion is salted and dried under the sun and sold as dried shrimp, processed into a locally known 'Belacan' paste, or pickled to produce a product called 'Chinchalok' [4, 10].

They are known by locals as 'Udang Geragau' in Malacca, 'Udang Baring' in Terengganu, while in Sabah and Sarawak it is generally recognized as 'Bubok' [11]. In Borneo Island, small-scale fishermen in Miri (Sarawak) were able to catch over 100 kg of *Acetes* shrimps a day during the *Acetes* fishing season and the catch was sold between RM7 and RM8 per kilogramme. The fresh shrimps were also marketed to the producers of 'belacan', which then sold the freshly made paste for RM50 per kilogramme [12]. Furthermore, a 'belacan' entrepreneur earns up to RM30,000 a month from the sale of the product [13] which suggests that *Acetes* is economically important in Malaysia to support the small-scale industries.

2. Materials and methods

This study covered the *Acetes* spp. landings from two Sabah waters: Kudat, and Tawau. These locations were chosen to represent the different geographical locations of Sabah. All available data related to the annual landings of *Acetes* spp. in Sabah over the past 30 years, from 1990 to 2019, were obtained from the Department of Fisheries Sabah. Besides that, data on the annual mean temperature (°C), annual rainfall summary (mm/day), and annual mean relative humidity (%) were acquired from the Meteorological Department of Sabah.

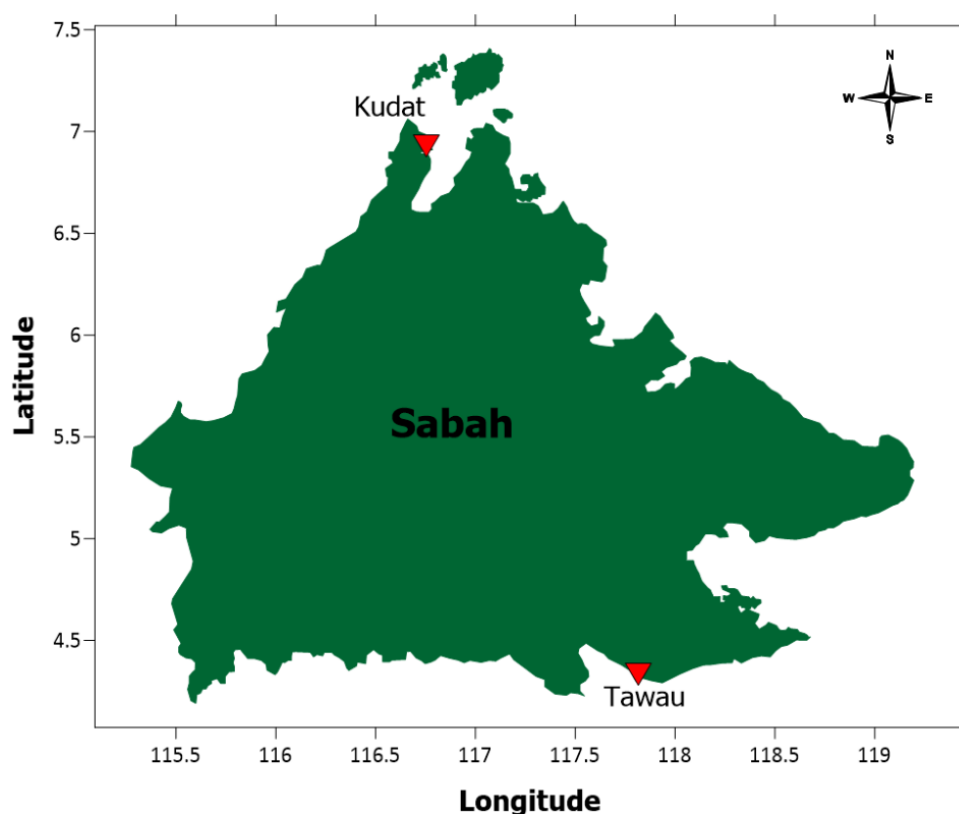


Figure 1. Locations in Sabah where the data were used for current study.

The one-way ANOVA was used to examine whether there were significant differences between different years on the annual landings of *Acetes*. The Pearson's correlation test was carried out to

measure the statistical association and to examine whether there was a positive or negative linear relationship between the annual *Acetes* landings and the environmental variables, which are relative humidity, rainfall, and annual mean temperature. The statistical analysis was done using the IBM Statistical Package for the Social Sciences (SPSS) software version 25.

3. Results

Both mean temperature and rainfall showed significant different between study area (p-value: 0.000 and 0.008 respectively) except the relative humidity (p-value: 0.466). The highest and lowest annual mean temperature for Kudat was in 1998 (27.95 ± 0.98 °C) and 2011 (26.88 ± 0.70 °C). Next, Tawau recorded its highest annual mean temperature in 2010 (27.31 ± 0.54 °C) and its lowest in 2003 (26.42 ± 0.37 °C). In Kudat, the highest total rainfall was 4222.10 mm in year 2011 as compared to the peak in Tawau 2618.30 mm (2006) while the lowest in both areas were 1343.60 mm (2002) and 1151.50 mm (1997) respectively.

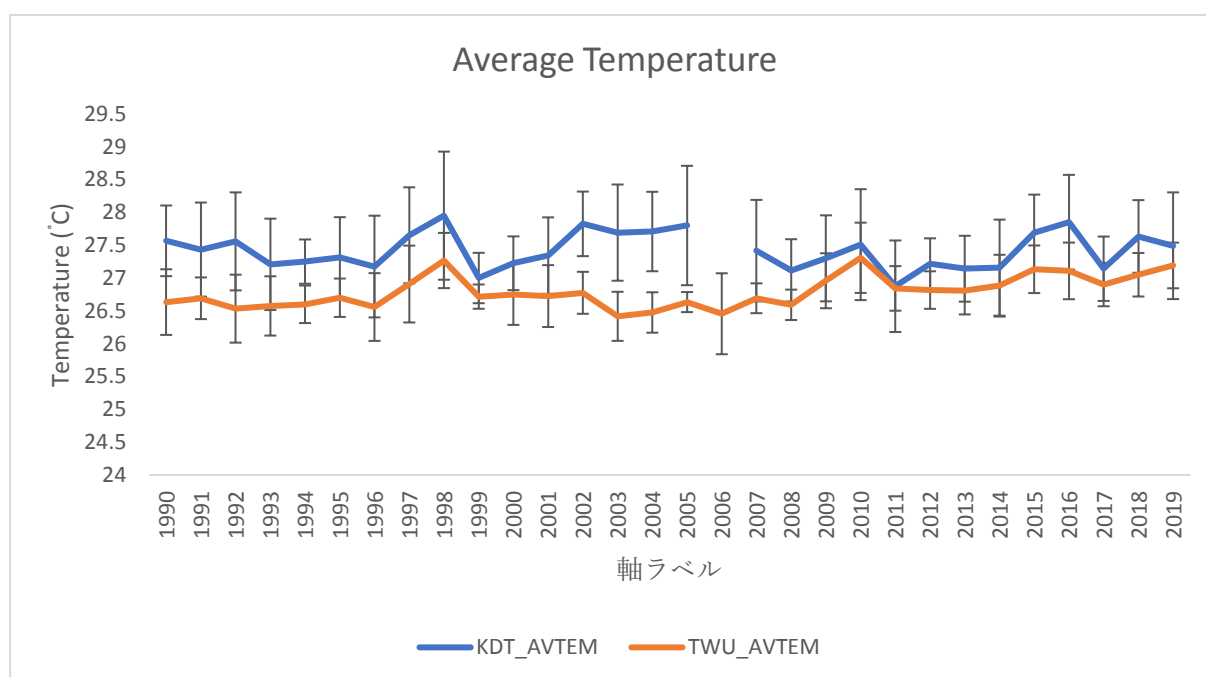


Figure 2. Average temperature of Kudat and Tawau from 1990 to 2019.

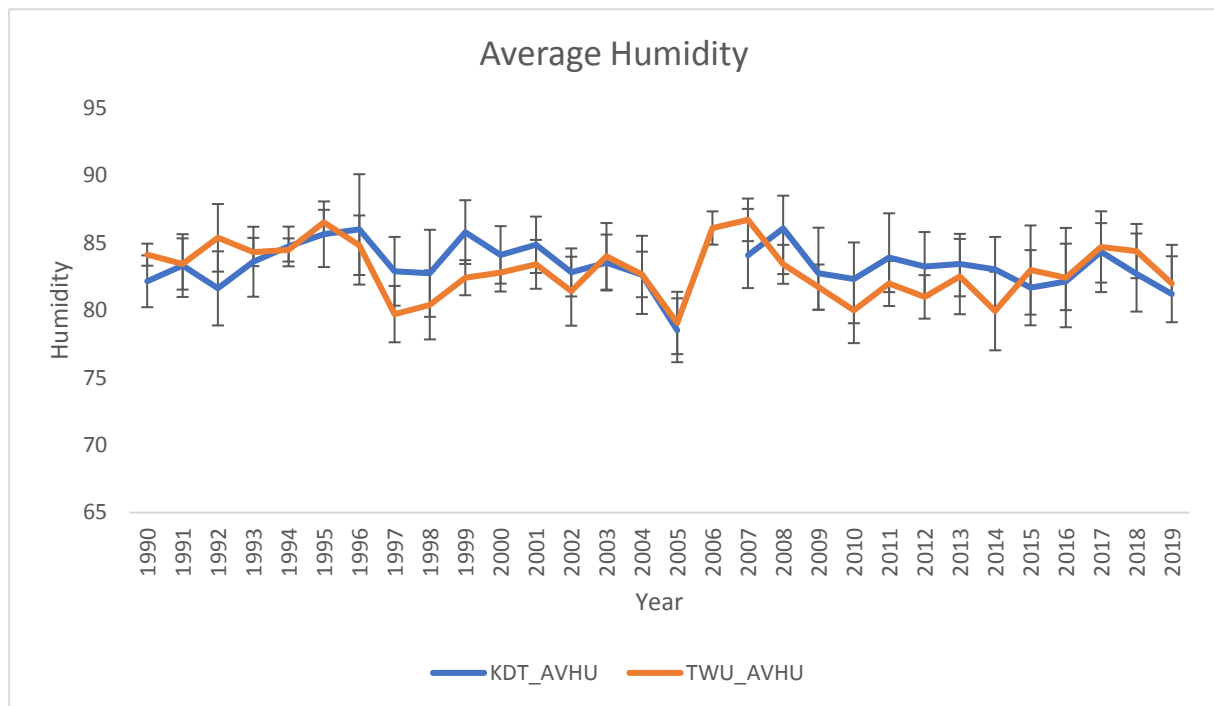


Figure 3. Average humidity of Kudat and Tawau from 1990 to 2019.

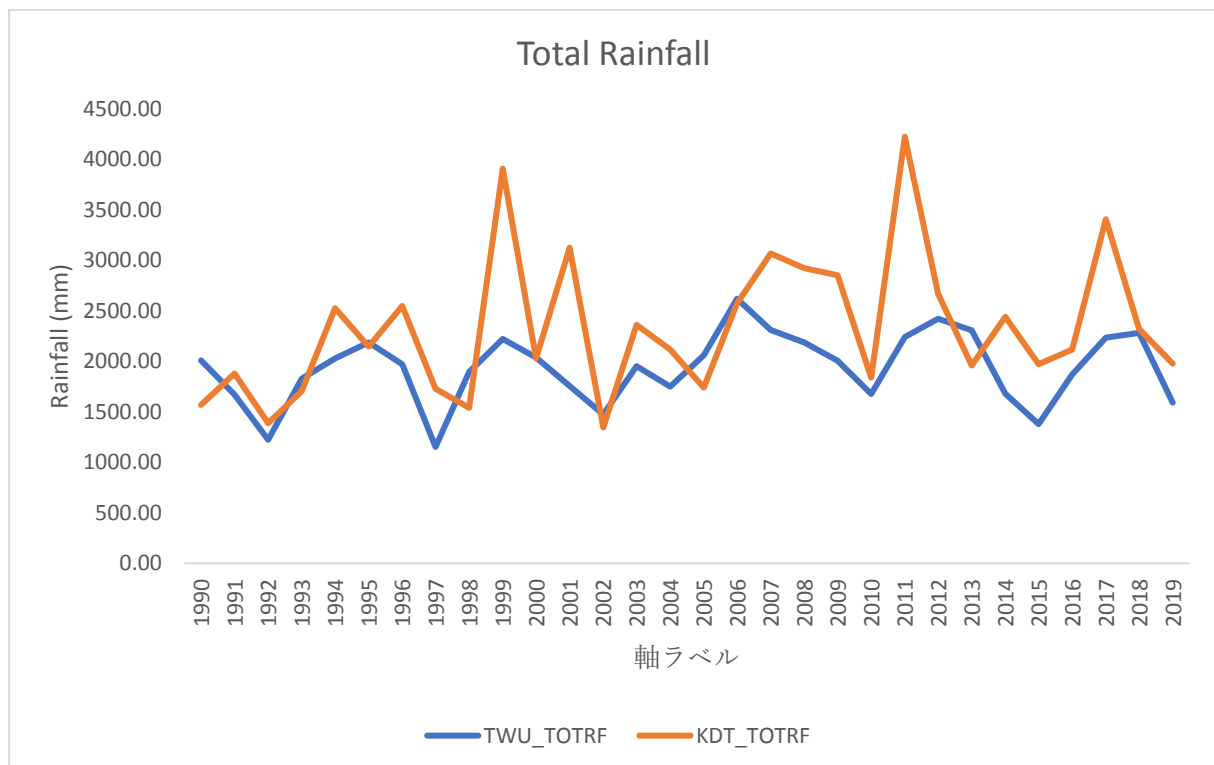


Figure 4. Total rainfall of Kudat and Tawau from 1990 to 2019.

Results of the One-way ANOVA analyses showed no significant difference in the landings of *Acetes* in the East Coast of Sabah between the 30 years (p-value: 0.997) but significantly different between area (Kudat and Tawau) for the past 30 years (p-value: 0.000). In general, the highest total landing in Kudat was recorded was in 2008 (29.23 metric tonnes) while most of the years were recorded with zero metric tonnes. The second study site was Tawau which recorded its highest landing in 2018 (192.71 metric tonnes) and lowest in 1990 (0.06 metric tonnes). Although Tawau showed an erratic trend in the landings throughout the past 30 years yet the overall trend was still increasing as compared to Kudat. Extreme low landings were recorded throughout the past 30 years in Kudat with the highest in year 2006 and 2008 but only 22.05 metric tonnes and 29.23 metric tonnes.

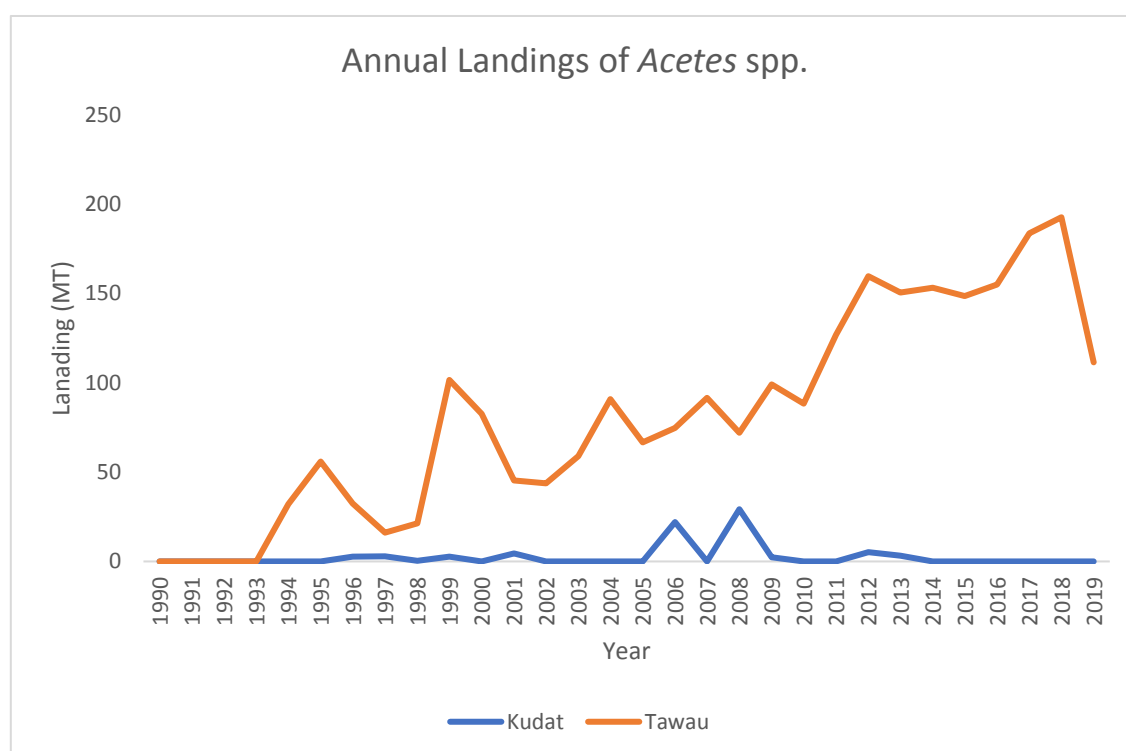


Figure 5. Annual landings of *Acetes* spp. in Kudat and Tawau from 1990 to 2019.

Results from the correlation tests showed weak negative correlations between the annual landings and relative humidity ($r=-0.405$; $p=0.029$) in Kudat. Furthermore, the correlation test also revealed that there is a strong positive correlation between the annual landings and year ($r=0.914$; $p=0.000$), temperature (0.435 ; $p=0.016$) and rainfall ($r=-0.376$; $p=0.041$) in Tawau.

4. Discussion

In Tawau, the results showed significant correlation between the landings and year. Despite a drop in the *Acetes* landings in certain years, overall, there is a steady growth in the landings of *Acetes* observed beginning in 2002. The significant increase in the early 2000s may be a result of the government effort that took place in 1996 where Malaysia's National Agricultural Policy (NAP) 3 (1998-2010) was initiated [14]. This policy provided a lot of subsidies to the Malaysian fishermen which includes monthly allowance, fishing equipment, fuel subsidy, fishing boats and fish landing jetty construction, installation of Automatic Identification System on fishing boats and several other facilities [15, 16].

The increase in annual landings may also be related to the growing fishing efforts of local fishermen as they are trying to grasp the rapid development of the byproduct industry, which includes the production of *belacan* and *cencaluk*, that is gaining popularity among Malaysians. Besides that, *Acetes* are also receiving increasing market demand as they are also one of the food organisms for aquaculture industry and are equally important for consumption by humans and domestic animals [10, 17]. Besides the growing market demand of *Acetes* in the country, the increase in number of fishing gears in Malaysia involved in the fisheries of *Acetes* from 2005 to 2010 as reported by Stephenie et al. (2021) [16], may also be one of the reasons for the increase in annual landings. It was mentioned that the main fishing gear used for capturing *Acetes* were trawl nets, bag nets, and push/scoop nets.

Fishing of *Acetes* typically begins within two weeks of the first rainy day as this is when the river discharge is the greatest and the *Acetes* will migrate from estuaries to deeper offshore waters. Moreover, heavy rainfall was reported to reduce the temperature of water, which is the ideal environment for the *Acetes* to thrive because they prefer colder surroundings [18]. Although the results of present study indicated that the temperature was positively affecting the *Acetes* landings in Tawau but contradicted with the results of the previous study by Hajisamae et al. (2014) [18] where *Acetes* spp. preferred an environment with lower temperature and slightly higher dissolved oxygen, salinity and pH. Yet, the temperature of present study was just reflecting the surface temperature of the region but not the *in situ* water temperature which cause immediate preferences of *Acetes* community in the region. The results of temperature in present study are indicating the climatic condition where higher landings were recorded during the warmer periods supported by the findings of Amin et al. in 2010 that the spawning behavior of *Acetes* was related to temperature of water, where highest spawning typically occurs in warmer months. Spawning which takes place in water with higher temperature would benefit the larvae by reducing the developmental time and promotion of growth [19]. It was found that the hatching success of *A. intermedius* decreases when the temperature of water became lower.

However, Kudat did show a moderate correlation on the landings throughout the past 30 years with the relative humidity yet with a lot of zero landings as compared to Tawau. This phenomenon triggers the doubt of the authors as if the impact of relative humidity is affecting the landings in Kudat or due to other impacts (local preferences, pollution, habitat destructions or migratory)? It is suspected that the low landings data could be the small scale of catchment by the locals as side income or personal consumptions instead of industry scale production. Besides that, many *Acetes* also perform vertical migration that is correlated to the diurnal cycles for various purposes, such as ontogenetic migration, population maintenance in estuary habitats, and avoidance of visual predators [20]. Hence, further research is suggested to be carried out to investigate the present phenomenon to ensure the sustainability of *Acetes* in the coastal waters of Sabah.

5. Conclusion

The landings of the sergestid shrimp, *Acetes* spp., in the east coast of Sabah were subjected to the impact of rainfall, surface temperature and most important is the expanding of industry. More intensive studies is suggested to be carried out to investigate the status of fisheries of sergestid shrimp to safeguard sustainable seafood for future generations.

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