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Population fluctuation and effectiveness of climate on the mango shield scale, *Milviscutulus mangiferae* (Hemiptera: Coccidae) in Al-Busayli, El-Beheira Governorate, Egypt

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Abstract

The mango shield scale, *Milviscutulus mangiferae* (Green) (Hemiptera: Coccidae) is a serious polyphagous pest of mango trees and many ornamental plants. Since the climatic conditions in Egypt are conducive to the establishment and spread of *M. mangiferae,* it is expected that it will have an economic impact in Egypt. The seasonal abundance of *M. mangiferae* was studied under the climatic conditions during the two seasons 2021 and 2022 in El-Beheira Governorate. The present results showed that *M. mangiferae* population exponentially increased from October to next January and reached the maximum peak in November and slightly increased in June and July. The immature stages were synchronized with the population fluctuation, where crawler, first and second nymphal stages recorded the highest peak 197.25, 107 and 112.2 in November 2021, respectively, and139.75, 98 and 97 in November 2022 seasons, respectively. The highest rate of monthly variation in the population (R.M.V.P.) value was recorded in June 2.23 and 2.66 for 2021 and 2022 seasons, respectively. On the contrary, the lowest value was shown in February and March. In conclusion, the changes in population fluctuation dynamics of *M. mangiferae* on mango trees were mostly related to the monthly changes in climate, especially daily temperature rates. The present findings will help in developing appropriate pest management strategies for *M. mangiferae*.

Introduction

Mango trees (*Mangifera indica* L.) (Anacardiaceae) are considered as one of the most popular and economic fruit in Egypt. In the world market, Egyptian mangoes occupy economic importance for its rich flavor and taste. Mango trees infected by several pests, the mango shield scale *Milviscutulus mangiferae* (Green) (Hemiptera: Coccidae) is considered one of the most main destructive pests of mango trees (Abd-Rabou and Evans, 2018; Attia *et al.*, 2018 and El-Baradey *et al.*, 2020).

The mango shield scale *M. mangiferae* a polyphagus species, was recorded Scale Net (2017) in 62 countries of the world on different host plants from 82 genera belong 42 families, including mangoes (*M. indica*), papaya (*Carica papaya*), avocado (*Persea americana*), breadfruit (*Artocarpus altilis*), Syzygium spp., Vanilla sp., guava (*Psidium guajava*), nutmeg (*Myristica fragrans*), coconut (*Cocos nucifera*), orange (*Citrus sinensis*) and lemon (*Citrus limon*) (Williams and Watson, 1990: CABI CPC, 2008 and Garcı´a Morales *et al.*, 2016). According to Ben-Dov *et al.*, (1975), the mango shield scale is distributed mainly in subtropical and tropical areas in all mango-producing countries. The suitable areas of the world in which *M. mangiferae* has become established are generally equatorial with hot and often humid summers. Although Scale insects in general establish very well in protected environments, *M. mangiferae* wasn't recorded on plants under protection, this may be due to its current distribution being such that its hosts would largely be grown outdoors. Ordinarily, this pest causes light infestations, it feeds by sucking the plant sap and it injures the shoots, twigs, leaves, branches and fruits (Soliman *et al.*, 2007; Hassan *et al.*, 2012 and Bakry *et al.*, 2013). Like other scale insects, this pest also excretes a large amount of honeydew that attracts ants and encourages the growth of sooty mold which affects photosynthesis and otherwise reduces the quality of the plant causing economic injury (Atalla *et al.*, 2007 and Nabil, 2013). Parthenogenesis is the dominant form of reproduction for these scale pests and males are seldom recorded. Adult females and older larvae of *M. mangiferae* are essentially sedentary and the adults die just after producing first-instar larvae. Only these early-stage larvae, or crawlers, can migrate to any extent and it is their movement that disperses a population (Kasuya, 2000).

Little information is available concerning the effect of the fluctuation of climate during the year on *M. mangiferae* population dynamics. Assessing the effectiveness of temperature and humidity will help in developing appropriate pest management strategies. Therefore, the present study aimed to record the meteorological data during the cropping period and evaluate its effect on *M. mangiferae* infestation during the year in Al-Busayli, El-Beheira Governorate, Egypt.

Materials and methods

1. Study area:

The present study was carried out in a private mango orchard, in Al-Busayli, El-Beheira Governorate, Egypt (31°19' 48.9" N 30°24' 12.9" E) (Figure 1).

Figure (1): Al-Busayli, El-Beheira Governorate, Egypt (31°19' 48.9" N 30°24' 12.9" E).

2. Meteorological data:

The monthly average of meteorological data (i.e. Maximum and minimum daily temperatures and mean percentage of daily relative humidity) was recorded during season of 2021 and 2022 cropping period in El-Beheira Governorate at the Central Laboratory for Agricultural Climate, Agricultural Research Center, Ministry of Agriculture, El-Beheira Governorate, Egypt. The meteorological data is presented in Table (1).

3. Samples:

The population fluctuations of this scale, which were found to affect mango trees at half-monthly intervals, were carried out at Al-Busayli, El-Beheira Governorate for two consecutive years from half-January 2021 to half-December 2022. The selected orchard received the practices normal agricultural practices without the application of any chemical control measures before and during the study period. Four mango trees of the Kit variety were selected, similar in age and as uniform as possible in size, shape, height, and vegetative growth. Regular, fortnightly samples were taken randomly from different directions and layers of trees at a rate of 20 leaves per tree. Samples were collected regularly and immediately transported to the laboratory in Plant Protection Station in Alexandria-Agricultural Research Center, Alexandria Governorate in polyethylene bags for examination using a binocular microscope. The numbers of live insects on the upper and lower surface of mango leaves were individually sorted into immature (Crawler and nymphs) and mature (Adult females) stages and then counted and recorded together against each date examined.

The rate of monthly variation in the population (R.M.V.P) was calculated according to the equation reported by Serag El-Dien (1998):

$$(R.M.V.P) = \frac{\text{Means count of insect at a month}}{\text{Means count of given at the preceding month}}$$

4. Statistical design:

Treatments were arranged in a Randomized Complete Block Design (RCBD) with four replicates during the two seasons.

5. Statistical Analysis:

All collected data were subjected to analysis of variance according to Gomez and Gomez (1984). Statistical analysis was performed using analysis of variance techniques using CoStat computer software package (CoStat, Ver. 6.311., 2005). The least significant difference (LSD at 0.05) was used to compare the treatment means.

Table (1): The monthly of the meteorological data in El-Beheira Governorate, Egypt during 2021 and 2022 seasons.

	Seasons							
	2021				**2022**			
Month	**Min Temp. (°C)**	**Max Temp. (°C)**	**Mean Temp.**	**R. H (%)**	**Min Temp. (°C)**	**Max Temp. (°C)**	**Mean Temp.**	**R. H (%)**
Jan.	14.71	19.52	17.11	71.40	11.97	16.34	14.16	69.54
Feb.	13.42	18.63	16.02	70.72	12.03	16.83	14.43	72.42
Mar.	13.69	18.80	16.24	69.63	12.21	17.34	14.77	69.20
Apr.	15.04	22.61	18.82	67.06	15.72	23.77	19.75	65.70
May	20.04	27.72	23.88	63.19	18.89	25.98	22.43	68.37
Jun.	22.44	28.91	25.68	65.65	23.29	29.49	26.39	67.63
Jul.	25.09	31.07	28.08	67.43	24.63	30.88	27.76	65.93
Aug.	26.09	32.59	29.34	67.24	25.67	30.98	28.32	67.10
Sept.	24.83	29.99	27.41	64.96	24.91	30.35	27.63	65.02
Oct.	22.11	27.18	24.64	65.45	22.68	27.08	24.88	65.55
Nov.	20.14	25.25	22.69	68.82	19.61	23.73	21.67	64.03
Dec.	15.25	19.09	17.17	69.59	16.82	21.53	19.18	69.78
Average	19.40	25.11	22.26	67.60	19.03	24.52	21.78	67.52

Data were collected from the Central Laboratory for Agricultural Climate, Agricultural Research Center, Ministry of Agriculture, El-Beheira Governorate, Egypt.

Results and discussion

1. Monthly fluctuations of *Milviscutulus mangiferae* different stages:

M. mangiferae population fluctuation was assessed simultaneously with major weather factors to determine the most appropriate timing for the application of control programs. The population structure is illustrated in Figures (2 and 3). This data indicates that the population dynamics in the two years 2021 and 2022 follow almost the same pattern. In the two surveyed seasons, the recorded number of mango shield scale insect population exponentially increased from October to January and reached the maximum peak in November. After January the population dramatically declined through the months of February to May and then slightly increased in June and July. The recorded crawler and nymphal stages were synchronized with the population fluctuation, where the crawler recorded the highest peak of 197.25 and 139.75 in November and the second peak of 84.50 and 72.25 was recorded in July for 2021 and 2022 seasons, respectively. The highest number of immature stages was recorded also in November 107 and 98 for the first nymphal stage and 112.2 and 97 for the second nymphal stage in 2021 and 2022 seasons, respectively.

Abbas *et al.* (2019) found that the nymphal stage and gravid females had three peaks for two years, while the adult female had four peaks during the two years per year. Mohamed (2020) and Bakry *et al.* (2020) showed there were three peaks of activity on mango trees for the total population. These findings are not compatible with El-Baradey *et al.* (2018) who recorded only two peaks of abundance per year for *M. mangiferae* on mango trees in Kafr El-Sheikh Governorate.

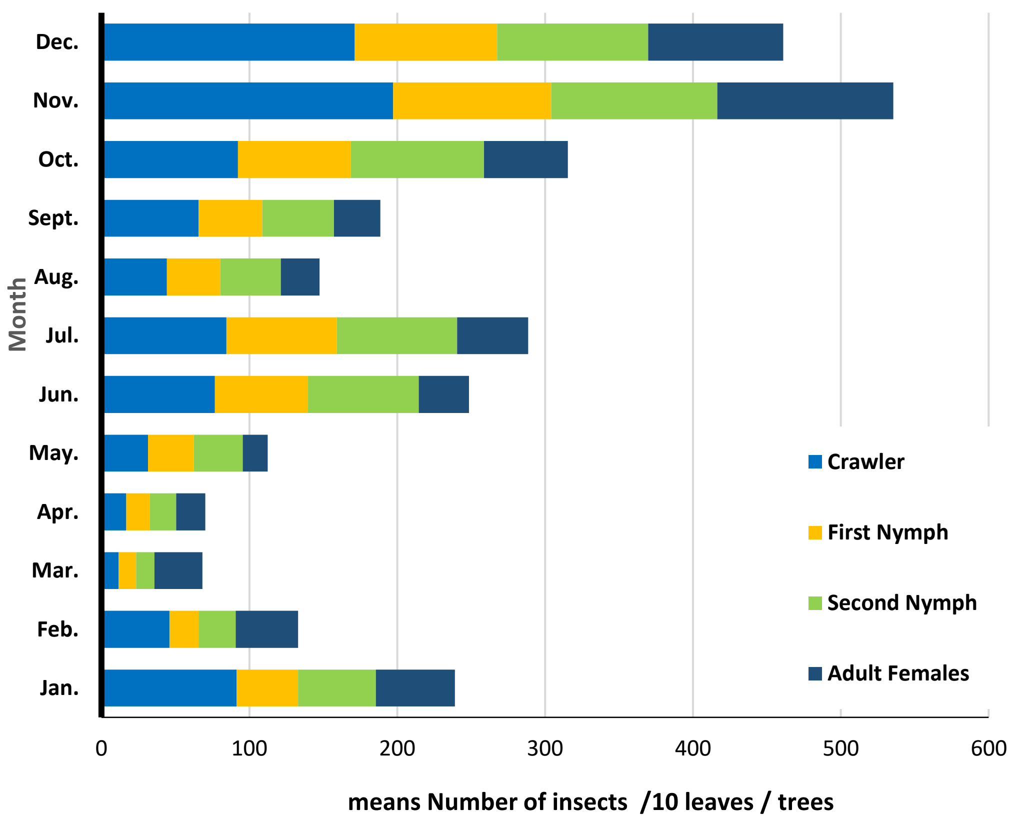

Figure (2): Monthly fluctuations of *Milviscutulus mangiferae* different stages on mango trees in Al-Busayli, El-Beheira Governorate during 2021.

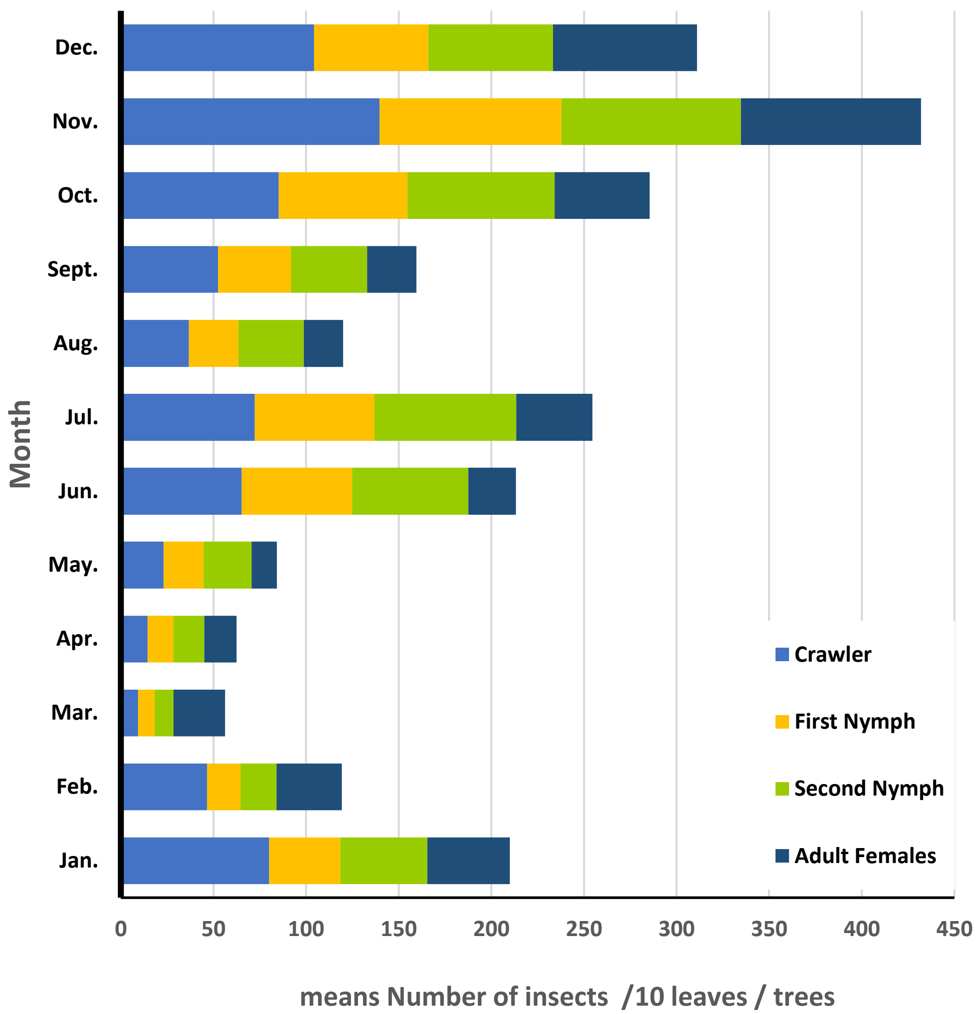

Figure (3): Monthly fluctuations of *Milviscutulus mangiferae* different stages on mango trees in Al-Busayli, El-Beheira Governorate during 2022.

2. The rate of monthly variation in the population (R.M.V.P) of *Milviscutulus mangiferae* different stages affected by monthly weather changes:

The rate of monthly variation in the population (R.M.V.P) was calculated and illustrated in Table (2), there was a significant difference between months. The highest R.M.V.P value was recorded at June 2.23 and 2.55 for 2021 and 2022 seasons, respectively, followed by October and November with no significant difference in 2021. On the contrary, the lowest value was shown in February and March. The obtained results showed that *M. mangiferae* completes two to three generations annually. In this respect, Attia *et al.* (2018) and Abbas *et al.* (2019) indicated the occurrence of three generations for *M. mangiferae* of mango trees at Qalubiya governorate.

3. Impact of some of the measured meteorological factors on *Milviscutulus mangiferae* rate of monthly variation in the population (R.M.V.P.).

The relationship between the meteorological data and R.M.V.P for 2021 and 2022 seasons was displayed in Figures (4 and 5), two seasons almost follow the same trend of R.M.V.P. in relation to different months. Generally, R.M.V.P significantly decreased during the cold months. The mean percentage of daily relative humidity changed in different months, and we found that it changed for the same month during two study seasons. These changes did not affect the R.M.V.P, which confirms that temperature is the main factor influencing the R.M.V.P. (Abbas *et al.* 2019), the temperature had positive highly effect on the changes in the population density of *M. mangiferae,* while the mean percentage of relative humidity showed a negative highly significant effect during the first year (2016-2017) and showed positive insignificant effects during (2017/18) on the changes of population density of *M. mangiferae*. On the contrary, Bakry *et al.* (2020) showed that mean relative humidity exhibited a highly significant positive effects on the total population.

Data presented in Figure (4), for season 2021, showed that when linking daily temperature rates with R.M.V.P., we found that the highest R.M.V.P., 2.25, corresponded to the temperature rates recorded in June (Minimum temperature 22.44°C and maximum temperature 28.91°C).

This R.M.V.P. decreased significantly with the extreme rise in temperatures (26.09°C and 32.59°C) that was recorded in August, and the R.M.V.P. rose again to form a second peak in October and November. In season 2022, Figure (5) showed that the R.M.V.P was 2.66 in June, which is synchronous with the temperature in June (Minimum temperature 23.29°C and maximum temperature 29.49°C).

In this respect, Attia *et al.* (2018), revealed that there was an abnormal relationship between the total population and the metrological factors. On the other hand, Mohamed (2020) reported a highly significant negative relation between daily mean maximum temperature and total population density, while daily mean relative humidity with total population density gave a significant positive relation in two seasons.

Table (2): Effect of monthly weather changes on total numbers and rate of monthly variation in the population R.M.V.P of *Milviscutulus mangiferae* different stages during the seasons 2021 and 2022.

Mon.	Adult Females		Crawler		First Nymph		Second Nymph		Total		R.M.V. P.	
	Season											
	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022
Jan.	53.50 c	44.50 c	91.50 c	80.00 d	41.50 e	38.50 d	52.50 e	47.00 d	239.00 f	210.00e	0.00 i	0.00 i
Feb.	42.25 e	35.25 e	46.00 g	46.50 h	19.75 h	18.00 fg	25.00 h	19.50 h	133.00 i	119.25g	0.56 h	0.57 g
Mar.	32.50 f	27.75 f	11.50 j	9.25 l	12.00 i	9.00 h	12.25 j	10.25 i	68.25 k	56.25 i	0.51 h	0.48 h
Apr.	19.75 h	17.50 h	16.75 i	14.50 k	16.00 hi	14.00 gh	17.75 i	16.50 h	70.25 k	62.50 i	1.03 f	1.10 e
May.	17.00 h	13.75 i	31.50 h	23.00 j	31.00 g	21.75 ef	33.00 g	25.75 g	112.50 j	84.25 h	1.61 c	1.35 d
Jun.	34.00 f	25.75 f	76.75 e	65.25 f	63.00 d	59.50 c	77.75 d	62.75 c	251.50 e	214.50 e	2.23 a	2.55 a
Jul.	48.00 d	41.00 d	84.50 d	72.25 e	74.75 c	64.75 bc	81.25 d	76.50 b	288.50 d	254.50d	1.15 e	1.19 e
Aug.	26.25 g	21.25 g	44.25 g	36.75 i	36.25 f	26.75 e	43.25 f	35.25 f	150.00 h	120.00g	0.52 h	0.47 h
Sept.	31.25 f	26.50 f	65.75 f	52.50 g	43.00 e	39.25 d	48.5 e	41.25 e	188.50 g	159.50f	1.26 d	1.33 d
Oct.	56.75 c	51.25 c	92.25 c	85.25 c	76.50 c	69.50 c	90.00 c	79.50 b	315.50 c	285.50c	1.67 bc	1.79 b
Nov.	119.0 a	97.25 a	197.25a	139.75a	107.0a	98.00 a	112.2 a	97.00 a	535.50 a	432.00a	1.70 b	1.51 c
Dec.	91.25 b	77.75 b	171.25 b	104.25b	96.25 b	61.75 c	102.25 b	67.25 c	461.00 b	311.00b	0.86 g	0.72 f
LSD 0.05	3.83	2.56	4.61	4.19	4.56	5.32	4.86	5.05	9.84	10.68	0.07	0.08

Means in the same column (s) followed by the same letter are not significantly different at $P < 0.05$ level of probability.

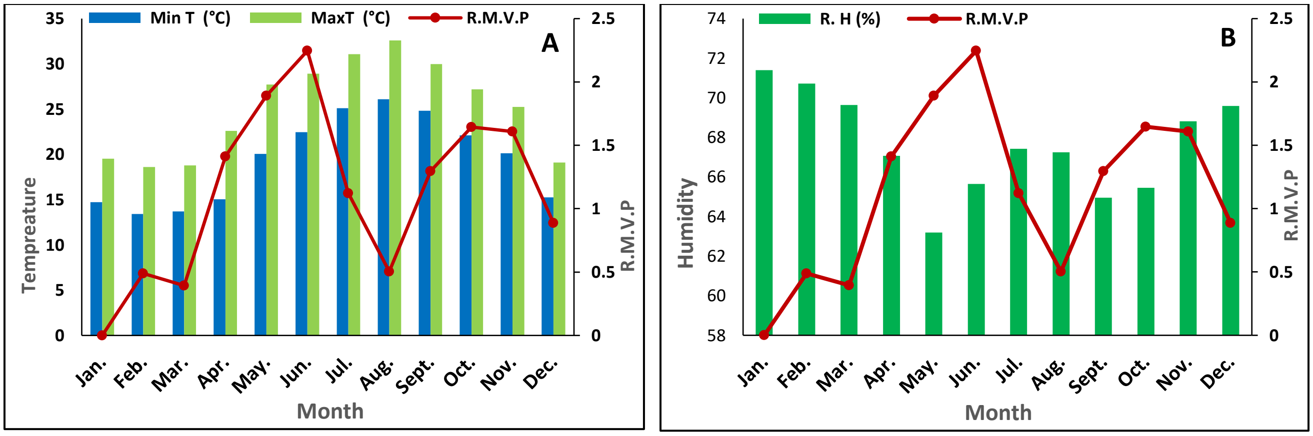

Figure (4): The relationship between the R.M.V.P value with the minimum and maximum daily temperatures (A) and with mean percentage of daily relative humidity (B) in 2021 season.

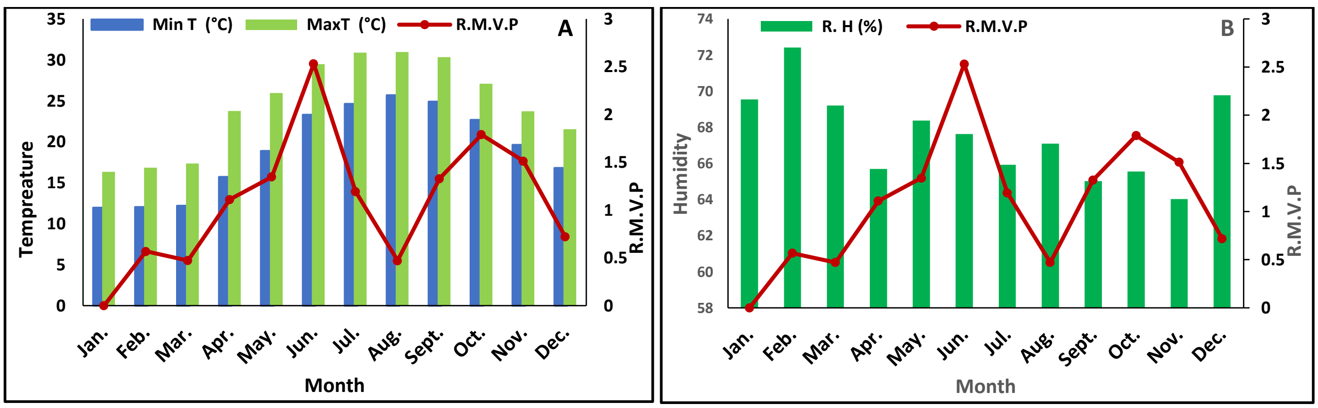

Figure (5): The relationship between the R.M.V.P value with the minimum and maximum daily temperatures (A) and with mean percentage of daily relative humidity (B) in 2022 season.

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