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Effect of climate changes on population fluctuation of some phytophagous mites and their predators on strawberry crop in Qalubia governorate.

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ABSTRACT

Survey was conducted to identify phytophagous, predaceous and miscellaneous feeding mite species from five locations in Qalubia governorate (Arab Elhassania, Arab Alkhilwa, Meet Kinana , Namol , Eldar) on two strawberry cultivars during two successive season (2019/2020 and 2020/2021). Taxa reported the occurrence of thirty-nine species representing of sixteen families. Among the species, eight belonging to tetranychid and tenuipalpid mite species dominated by *Tetranychus urticae*. Seventeen species of predators belonging to six families are recorded (Phytoseiidae, Ascidae, Stigmaeidae, Cunaxidae, Bdellidae and Digamasellidae). The most common predator on plants was *Phytoseiulus persimilis* **Athias-Henriot**. Population dynamics of *Tetranychus urticae* **Koch** and its predator *Phytoseiulus persimilis* were recorded on two strawberry cultivars during the two seasons. The population of *T. urticae* reached their high peaks of infestation in the third week of March and the first week of February (12.63 & 35.60) during 2019/2020 and in the last week of January and February (9.30 &15.93) mean number /30 leaflet during 2020/2021 for moving stages, Fortona and Florida cultivars respectively. The phytoseiid mite, *P. persimilis* was recorded in association with the population of *T. urticae*, when it appeared in high peak in the first week of March and the first of January (2.33&4.40 and 2.43& 1.95) mean number /30 leaflet for moving stages during the two seasons of the study respectively. Populations of *T. urticae and P. persimilis* showed a positive correlation with average temperature and negatively correlated with relative humidity.

Key words: Survey, Population dynamics, *T. urticae*, *P. persimilis*, Climate changes.

INTRODUCTION

Strawberry (*Fragaria x ananassa* Duch.) is one of the most important members of the family Rosaceae. It has become one of the most economic vegetable crops in Egypt and considered the main cash crop for strawberry growers in most governorates, concerning the amount of crop production; Egypt is the fourth largest strawberry producer in the world **(Essa 2015) [6].**

Strawberry, a widely cultivated pseudo fruit approximately 4.6 million tons in 2011(**FAO, 2013) [7],** consumed in nature or processed as juice and jelly, the ripe fresh strawberry fruits are rich in vitamins and minerals (**Khunte *et al.* 2020) [12]**, has high ascorbic acid (vitamin C) levels, as well as high levels of polyphenolic compounds (mainly anthocyanins), all compounds associated with health benefits (**Kalt, 2001[10], Amaro *et al.* 2012[3]) .**

Strawberry is liable to be attacked by several pests which are responsible for considerable quantitative and qualitative losses in the fruit yield **(Rings and Neiswander, 1966) [24]**.The phytophagous spider mite, *Tetranychus urticae* considered one of the main pests which attack strawberry plants **(wyoski, 1985) [27]**, cause direct economic damage to leaves, fruits, flowers and on tips of shoots **(Lourenção *et al.*, 2000**) **[15]**. **Huffaker *et al.* (1970) [9]** listed the four elements that contribute to spider mite dynamics including weather factors and natural enemies; nevertheless, temperature was found an important regulatory factor for *T. urticae* build up for many vegetable crops with positive correlations (**Haque *et al.*, 2011) [8].**

The predator *Phytoseiulus persimilis* **Athias-Henriot**, **1957** (Acari: Phytoseiidae) is the most well-known and the most widely distributed globally **(Demite *et al.*, 2018[5]; Migeon and Dorkeld, 2018[19]).**

The present study was carried out to know the seasonal incidence and population fluctuation of phytophagous mites and their natural enemies association on strawberry cultivars in Qalubia governorate, Egypt during two successive season (**2019/2020 and 2020/2021)**.

MATERIALS AND METHODS

Survey and population fluctuation studies of some mite species associated with strawberry crop:

This study was performed during two successive years (2019/2020 and 2020/2021) on two strawberry cultivars (Fortona & Florida Beauty). The strawberry samples were collected from five locations in Qalubia governorate (Arab Elhassania, Arab Alkhilwa, Meet Kinana, Namol, and Eldar). Samples of strawberry plant leaflet were randomly collected in early morning from infested fields every two weeks, and kept in separate plastic bags; each sample consisted of 30 leaflets from each cultivar.

The leaflet samples were directly examined by stereo–microscope, and collected individuals of mites cleared in Lactic acid, which quickly killed and stretched their bodies. Mite individuals were picked from clearing solution and singly mounted

in a drop of Hoyer's medium on glass slide and Labels containing all necessary information such as locality, date of collection, cultivar name, and mite stage were stuck on a side of the slides.

Slides was put in 40- 45°C oven for 4-5 days to stretch mite individuals and hasten the clearing process, and then located in slide box horizontally. All mite species were identified with the aid of research microscope, the identification of mites was based on illustrated scientific keys, followed by **Chant (1965**) **[4]**, **Mahunka (1970) [16]**, **Meyer (1974) [17]**, Krantz **(1978) [13], Meyer (1979) [18]** and **Zaher (1986**) **[28]**. Number of mite species were recorded and classified according to their abundance. Slides kept at the Acarology laboratory of Plant Protection Department Faculty of Agriculture Benha University.

The different stage of *T. urticae* and *P. persimilis* were counted using a stereomicroscope to estimate periodical incidence of all each mite stages on 30 leaflet for each cultivar, after three weeks from germination until harvest every two weeks , numbers of mite (eggs and moving stages) were counted in 2.5 cm^2 area of the leaflet underside. While, the predator mite were counted in the whole leaflet area **Poe (1980**) **[21]**. During the study periods, average temperature and relative humidity degrees was registered daily. All records were obtained from the Central Laboratory for Agricultural Climate, Plant Protection Research Institute, Agricultural Research center, Cairo, Egypt. Correlation between population dynamics and average temperature, relative humidity, and correlation coefficient was calculated.

Results and Discussion

I- Survey of mite species associated with strawberry crop:

Data in **Table (1)** showed that 39 mite species belonging to 16 families were determined in the total collected samples from two strawberry cultivars.

Table (1) Survey of mite species associated with two strawberry cultivars in Qalubia Governorate during two successive season (2019/2020 and 2020/2021)

Family	Mite species	plant cultivar	Locality	Remarks
Phytophagous mites				
1- Tetranychidae Donnadieu , 1875	*Tetranychus urticae* **Koch**	Fortona & Florida	Arab Elhssania- Arab Alkhilwa -Meet kinana Eldar - Namol	High
	Tetranychus cucurbitacearum **(Sayed)**	Fortona & Florida	Arab Elhssania- Arab Alkhilwa -Meet kinana Eldar - Namol	High
	Tetranychus cinnabarinus **(Boisduval)**	Fortona & Florida	Arab Elhssania- Eldar Namol	Moderate
	Tetranychus attiahi **Zaher, Gomaa and El-enany**	Fortona & Florida	Meet kinana Eldar - Namol	Rare
	Eutetranychus orientalis **(Klein)**	Fortona	Eldar - Namol	Rare
2-**Tenuipalpidae Berlese , 1913**	*Cenopalpus lanceolatisetae* **(Attiah)**	Fortona	Namol	Rare
	Brevipalpus californicus **(Banks)**	Fortona & Florida	Meet kinana - Eldar Namol	Low
	Tenuipalpus granati **Sayed**	Florida	Eldar	Rare
Predaceous mites				
1-Phytoseiidae Berlese ,**1916**	*Phytoseiulus persimilis* **Athias - Henriot**	Fortona & Florida	Arab Elhssania - Arab Alkhilwa -Meet kinana Eldar - Namol	Moderate
	Amblyseius cydnodactylon **Sheheta and Zaher**	Fortona & Florida	Namol	Rare
	Amblyseius swirskii **Athias-Henriot**	Fortona & Florida	Arab Alkhilwa-Eldar	Moderate
	Phytoseius finitimus **Ribaga**	Florida	Meet kinana -Eldar Namol	Rare
	Amblyseius enab **Elbadry**	Fortona	Eldar - Namol	Rare
	Euseius scutalis **(Athias-Henriot)**	Fortona & Florida	Arab Elhssania- Arab Alkhilwa -Namol	Rare
	Amblyseius cucumeris **(Oudemans)**	Fortona & Florida	Arab Elhssania- Arab Alkhilwa -Meet kinana Eldar – Namol	Moderate

2-Ascidae Voigts and Oudemans , 1905	*Proctolaelaps aegyptiaca* **Nasr**	Fortona	Eldar - Namol -Meet kinana	Moderate
	Proctolaelaps orientalis **Nasr**	Fortona	Eldar - Namol	Rare
	Protogamesellus denticus **Nasr**	Fortona	Namol	Rare
	Proctolaelaps pygmeaus **(Muller)**	Fortona	Eldar - Namol	Rare
3-Stigmaeidae Oudemans , 1931	*Agistemus exsertus* **Gonzales**	Fortona & Florida	Eldar - Namol	Low
	Mediolata pentascutus **Zaher and Gommaa**	Florida	Arab Elhssania	Rare
4-Cunaxidae Thor, 1902	*Cunaxa capreolus* **(Berlese)**	Fortona	Eldar - Namol	Rare
	Pulaeus niloticus **Zaher and Elbishlawy**	Florida	Eldar - Namol	Rare
5-Bdellidae Duges , 1834	*Spinibdella bifurcate* **Atyeo**	Florida	Namol	Rare
6-Digamasellidae Evans , 1957	*Dendrolaelaps aegypticus* **Metwally and Mersal**	Florida	Namol	Rare
Uncertain feeding behavior mites				
1-fam:Tydidae Kramer,1877	*Tydeus californicus* **(Banks)**	Fortona	Meet kinana -Eldar	Rare
	Tydeus kochi **Oudemans**	Fortona	Eldar - Namol	Rare
	Paralorryia zaheri **Baker**	Fortona	Namol	Rare
2-**Ameroseiidae Evans** , **1961**	*Kleemannia plumosus* **(Oudemans)**	Florida	Arab Elhssania- Arab Alkhilwa	Rare
	Kleemannia aegypticus **Nasr**	Florida	Arab Elhssania- Arab Alkhilwa	Rare
3-Oppiidae Grandjean , 1954	*Oppiella agypticae* **ElBadry and Nasr**	Fortona & Florida	Namol	Rare
4-Camerobiidae Southcott , **1957**	*Neophyllobius* sp.	Florida	Namol	Rare
5- **Acaridae Ewing and Nesbitt** , **1802**	*Rhizoglyphus robini* **Claparede**	Fortona & Florida	Arab Elhssania- Arab Alkhilwa -Eldar- Namol	Low
	Caloglyphus mycophagus **(Megnin)**	Fortona & Florida	Namol	Rare
	Lepidoglyphus destructor **(Schrank)**	Fortona & Florida	Arab Elhssania- Arab Alkhilwa -Eldar - Namol	Low
6-**Tarsonemidae Kramer**, **1877**	*Locustacarus* sp.	Fortona	Meet kinana -Eldar	Rare
	Tarsonemous meyerus **Soliman and Kandeel**	Fortona	Namol	Rare
7- Rhagidiidae oudemans , **1922**	*Shibaia* sp.	Fortona	Namol	Rare
8-**Eupodidae Koch, 1842**	*Eupodes niloticus* **AbouAwad and ElBagoury**	Florida	Namol	Rare

High = cosmopolitan, recorded in all sample
Moderate = Record in 60% of sample
Low = Record in 10% of sample
Rare = Record in less than 5% of sample

The phytophagous mites of this study were represented by two families, Tetranychidae (five species), *Tetranychus urticae* Koch was one of the most important pests of several agricultural crops and this species was recorded in all leaflet samples collected from five localities and also *T. cucurbitacearum* **(Sayed),** while *T. cinnabarinus* **(Boisduval**) in moderate numbers, but *T. attiahi* **Zaher**, **Gomaa and El-enany**, *Eutetranychus orientalis* **(Klein)** were found by rare numbers; and Tenuipalpidae were represented by three species, *Brevipalpus californicus* **(Banks**) where found in low numbers, and *Tenuipalpus granati* **Sayed,** *Cenopalpus lanceolatisetae* **(Attiah)** in rare numbers.

The Predaceous mites, which play an important role in biological control of mites, were represented by 17 species belonging to 6 families, Family: Phytoseiidae **,** is represented by 7 species, *Phytoseiulus persimilis* **Athias-Henriot ,** This species proved to be the most dominant phytoseiid mite on strawberry plant; *Euseius scutalis* **(Athias-Henriot)** was collected with few numbers also *Phytoseius finitimus* **Ribaga ,** under the genus Amblyseius 3 species were recorded viz., *Amblyseius swirski* **Athias-Henriot** *, A. cucumeris* **(Oudemans)** in moderate numbers, while *A. enab* **Elbadry** *and A. cydnodactylon* **Sheheta and Zaher,** by rare numbers . Family: Ascidae**,** this family harbored four mite species, *while Proctolaelaps pygmeaus* **(Muller)**, *P. orientalis* **Nasr** *and Protogamesellus denticus* **Nasr** *was* found at Eldar and Namol with rare numbers, while *Proctolaelaps aegyptiaca* **Nasr** *was* collected in moderate numbers from three districts.

Family**:** Stigmaeidae, two members of this family were recorded, these are *Agistemus exsertus* **Gonzales** in moderate numbers, but *Mediolata pentascutus* **Zaher and Gommaa,** by rare numbers. Family**:** Cunaxidae**,** included two mite species as: *Cunaxa capreolus* **(Berlese)** and *Pulaeus niloticus* **Zaher and Elbishlawy**, were recorded in rare numbers from Eldar and Namol districst. Family**:** Bdellidae**,** represent by single species, *Spinibdella bifurcate* **Atyeo** found by rare numbers and Family**:** Digamasellidae also represent by single species, *Dendrolaelaps aegypticus* **Metwally and Mersal** , found on Florida cultivar by rare numbers at Namol district.

In this study were represented as eight different families uncertain feeding behavior mites: namely**;** Tydeidae **,** Three species *Tydeus californicus* (**Banks**) , *Tydeus kochi* **Oudemans** and *Paralorryia zaheri* **Baker** by rare numbers ; Ameroseiidae :two species (*Kleemannia plumosus* **(Oudemans)** and *Kleemannia aegypticus* **Nasr)**; Oppidae**:** one mite species as ,*Oppia egyptiaca* **El-Badry and Nasr** with rare numbers; Camerobiidae one members of this family as**,** *(Neophyllobius* sp) ; Acaridae: only three mite species, *Rhizoglyphus robini* **Claparede** and *Lepidoglyphus destructor* (**Schrank**) low numbers ,while *Caloglyphus mycophagus* **(Megnin)** found by rare numbers ; Tarsonemidae**:** two species *Locustacarus* sp. , *Tarsonemous meyerus* **Soliman and Kandeel** were collected from only Fortona cultivar by rare numbers; Rhagidiidae: represent by single species *Shibaia* sp.; Eupodidae one species *Eupodes niloticus* **AbouAwad and ElBagoury,** also was found with rare numbers.

These result similar to, **Rai (2011) [22]** recorded ten mite species on 15 commonly grown vegetables belonged to Tetranychid, Tenuipalpid , Eriophyid and Tarsonemid mites. The predatory mites found associated with vegetables belonged to five families viz., Phytoseiidae, Stigmaeidae, Tydeidae, Cunaxidae and Bdellidae. **(Sadanandan and Ramani, 2006[25]; Karmakar and Gupta, 2010[11]).** Investigated phytophagous and predatory mites associated with vegetable plants in Riyadh, Saudi Arabia **Al-Atawi (2011) [2]**. Also **Özsisli and Çobanoğlu (2011) [20]** collected phytophagous mites, *Tetranychus turkestani* (Ugarov & Nikolski) and *T.* cinnabarinus Boisduval and the predatory mites, *Phytoseius finitimus* Ribaga and *Amblyseius andersoni* (Chant) from eggplant and cucumber, respectively.

II- Population dynamic of *T. urticae* and *P. persimilis* on strawberry cultivars:

The population of *T. urticae* and *P. persimilis* on two strawberry cultivars (Fortona and Florida) in two successive seasons.

Data in **Table (2)** showed that, the populations of *T. urticae* during season 2019/2020 appeared with two peak for (Fortona and Florida) cultivars, respectively, the highest was in the third week of March and the first of February (12.77&20.17 and 12.63 & 35.60) mite individuals per leaflet for eggs, moving stages respectively . The second peak occurred in the first and third week of January with **(**11.67&6.40 and11.33&9.30) mite individuals per leaflet for eggs, moving stages respectively.

The results showed that, the peaks of predatory mite populations appeared in the end of December and the beginning of March, the first one was the lowest with (0.77&1.12 and 1.30& 1.29) mite individuals per leaflet for eggs, moving stages respectively. The second peak was the highest one (1.09&2.87 and 2.33&4.40) mite individuals per leaflet for eggs, moving stages respectively.

Table (2) Population dynamic of *Tetranychus urticae* and *Phytoseiulus persimilis* on two strawberry cultivars variety during season 2019-2020

Sampling date	Mean number per 30 leaflet								Weather factors	
	T. urticae				*P. persimilis*					
	Eggs		Moving stages		Eggs		Moving stages		Temp.	R.H.
	Fortona	Florida	Fortona	Florida	Fortona	Florida	Fortona	Florida		
2-10-2019	0.04	0.22	0.08	0.11	0.01	0.00	0.02	0.00	27.1	55
16-10-2019	0.07	0.39	0.11	0.06	0.01	0.00	0.01	0.00	26.8	65.4
30-10-2019	0.40	1.00	0.47	0.07	0.00	0.00	0.03	0.00	23.1	64.7
13-11-2019	1.37	2.33	1.37	2.00	0.01	0.11	0.12	0.13	25.1	47.3
27-11-2019	3.19	3.38	2.53	3.67	0.01	0.13	0.40	0.24	20.2	27.4
11-12-2019	3.83	3.57	3.37	3.90	0.07	0.22	1.00	0.37	17.2	45
25-12-2019	4.43	3.64	3.87	4.57	1.09	1.12	1.30	1.29	15.4	46.1
8-1-2020	5.80	6.40	4.33	9.30	0.22	0.13	0.17	0.10	12.1	53.1
22-1-2020	11.67	3.70	11.33	5.90	0.00	0.10	0.10	0.23	12.8	55.4
5-2-2020	7.10	20.17	10.63	35.60	0.24	0.97	0.73	0.40	16.8	52.8
19-2-2020	1.57	5.90	6.67	11.10	0.27	1.14	0.98	1.19	13.9	71.2
4-3-2020	0.40	5.84	3.50	5.17	0.77	2.87	2.33	4.40	19.1	47
18-3-2020	12.77	4.01	12.63	2.37	0.47	1.23	1.20	0.18	14.8	51.2
1-4-2020	0.23	3.01	6.13	1.23	0.17	0.43	0.17	0.13	19.4	53.7
15-4-2020	0.11	0.10	0.01	1.20	0.15	0.07	0.12	0.11	21.8	47.4
29-4-2020	0.02	0.07	0.05	0.09	0.11	0.11	0.11	0.10	20.2	49.1
13-5-2020	0.01	0.11	0.09	0.04	0.09	0.12	0.09	0.00	26.2	32.2
(r) Temp	0.73	0.87	0.66	0.82	0.17	0.25	0.23	0.31		
(r) R.H.	0.17	0.24	- 0.26	- 0.40	0.54	0.46	- 0.12	- 0.47		

(r) Temp Simple correlation coefficient between pest population and mean temperature.
(r) R.H. Simple correlation coefficient between pest population and mean relative humidity.

Data in **Table (3)** showed that the population of *T. urticae* has a single peak in the month of January and February, it was (5.78 &12.57 and 9.30 &15.93) mite individuals per leaflet for eggs, moving stages respectively. While the predacious mite, *P. persimilis* recorded two peaks, in the third week of January was (1.08 &1.87 and 2.43& 1.95) mites/leaflet for eggs, moving stages, Fortona and Florida cultivars respectively in the first peak, while in the second one were (0.23 & 0.22 and 0.27 &0.39) mite individuals per leaflet for eggs, moving stages respectively in third week of March and the first week of April.

III- The relationship between *T. urticae* and *P. persimilis* populations, and the climate changes on the strawberry cultivars.

The correlation study of mite population with a biotic factors, average temperature and relative humidity were also worked out (Table 2&3). The population of *T. urticae* showed a strong positive correlation with temperature where (r = 0.73 &0.87 and 0.66 & 0.82) during season 2019/2020 and (0.61 &0.80 and 0.67&0.72) during season 2020/2021 for eggs, moving stages, Fortona and Florida cultivars respectively, which means that high population of the *T. urticae* go with high degree of temperatures ; however population was negatively correlated with relative humidity where (r = - 0.26 & - 0.40 and - 0.19 & - 0.22) for moving stages, Fortona and Florida during the two seasons of the study, respectively. Population of *P. persimilis* was weak positively correlated with temperature for both the season where (r = 0.17 & 0.25 and 0.11 & 0.19) for eggs and (r = 0.23 & 0.31 and 0.19 &0.22) for moving stages, Fortona and Florida cultivars during the two seasons of the study, respectively, but showed negatively correlated with relative humidity (r = -.0.12 & - 0.47 and - 0.40 & - 0.33) for moving stages, Fortona and Florida cultivars for the two seasons of the study, respectively.

These results are in agreement with **Haque *et al.* ((2011)[8]** found that temperature had a positive effect on mite population on many vegetable. Also, **Singh (2016) [26]** noticed that predatory mites were positively correlated with temperature. Temperature has been the most extensively studied of all-weather factors and it appears to have great effects **(Riahi *et al.*, 2011[23]; Haque *et al.*, 2011[8])**. **Labanowska and Chlebowska (1998) [14]** recorded the highest population of *T. urticae* during June on strawberry in Poland. **Afifi *et al.* (2010) [1]** who observed variation in the mean densities of *T. urticae* on two strawberry cultivars (Charlie and Camarosa) in Egypt.

Table (3). Population dynamic of *Tetranychus urticae* and *Phytoseiulus persimilis* on two strawberry cultivars variety during season 2020-2021

Sampling date	Mean number per 30 leaflet									
	T.urticae				*P.persimilis*				Weather factors	
	Eggs		Moving stages		Eggs		Moving stages		Temp.	R.H.
	Fortona	Florida	Fortona	Florida	Fortona	Florida	Fortona	Florida		
20/09/2020	0.10	0.09	0.13	0.15	0.00	0.00	0.00	0.00	28.9	63.1
04/10/2020	0.27	0.17	0.07	0.17	0.00	0.00	0.01	0.00	26.3	58.4
18/10/2020	1.00	0.20	0.06	1.13	0.01	0.00	0.01	0.00	27.3	53.5
01/11/2020	1.55	0.37	1.01	1.23	0.01	0.07	0.02	0.05	23.3	58.1
15/11/2020	1.77	2.97	1.20	1.30	0.11	0.15	0.13	0.19	19.8	59.6
29/11/2020	2.17	3.30	2.67	2.47	0.19	0.22	0.21	0.30	17.7	62.4
13/12/2020	2.40	4.85	3.27	3.30	0.23	0.29	0.25	0.49	21.7	27.8
27/12/2020	3.80	5.47	4.73	4.30	0.33	0.44	0.54	0.58	16.1	73.2
10/01/2021	5.08	5.50	5.13	5.26	0.35	0.76	0.60	0.87	17.7	89.5
24/01/2021	5.78	12.57	6.63	15.93	1.08	1.87	2.43	1.95	14.9	65.3
07/02/2021	4.37	2.63	8.37	4.80	0.32	0.37	0.38	0.44	17.5	66.4
21/02/2021	3.73	2.23	9.30	3.27	0.13	0.17	0.13	0.11	12.8	63.2
07/03/2021	1.97	1.30	1.77	3.19	0.07	0.13	0.12	0.37	17.7	63.8
21/03/2021	1.00	0.19	1.17	1.17	0.03	0.14	0.03	0.39	25.3	43
04/04/2021	0.07	0.17	0.57	0.20	0.23	0.22	0.27	0. 27	20.2	37.1
18/04/2021	0.03	0.13	0.17	0.17	0.03	0.13	0.07	0.17	32.2	19.8
02/05/2021	0.23	0.01	0.07	0.11	0.00	0.04	0.01	0.07	28.2	27.7
(r) Temp	0.61	0.80	0.67	0.72	0.11	0.19	0.19	0.22		
(r) R.H.	0.12	0.16	- 0.19	- 0.22	0.26	0.31	- 0.40	- 0.33		

(r) Temp Simple correlation coefficient between pest population and mean temperature.
(r) R.H. Simple correlation coefficient between pest population and mean relative humidity.

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