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Development of mulberry pyralid Walker (*Glyphodespyloalis*, Crambidae: Lepidoptera) and its natural enemies classification

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ABSTRACT

The analysis of experiences results on investigation of mulberry pyralid development and identification of classification of order and family compositions its natural enemies in climate conditions of Andijan region has been presented. It has been shown that the least the butterflies fertility corresponds to temperature 15°C and the most one to 35°C. The analogical degrees for duration of butterfly's life correspond to 45°C and 15°C, correspondingly. These values are evidencing that the mulberry pyralid butterflies lay more eggs on high temperatures, however on these temperatures duration of their staying in the butterfly stage is being decreased. For mulberry pyralidboth eggs and larva has been revealed that the least survivability corresponds to temperature 15°C, as the same time the most one – to 25-30°C; duration of staying in the eggs stage of mulberry pyralid on environment temperature 15°C equals approximately to 8 days which is decreasing when temperature is increasing,reachesdown to 3 days on temperature 35°C. For other development stages decreasing of staying periods in these cycles is observing. For mulberry pyralid one total generation period must be from 28 up to 60 days and it is also decreasing when temperature is increasing. The comparative studying analysis of mulberry trees damaging in 2016 and 2017 showed that the most damaging degree of trees in 2016 on September (24%) and the least on June (8%) have been observed. The analogical values for 2017 (31% and 9%) to one month were removed, moreover the most value to one month before and the least after one month were removed. 10 species of predatory enemies entering to 4 families and 4 orders have been revealed. From which members of Neuroptera, Coleoptera and Hemiptera orders feed basically mulberry pyralid larva and eggs and as the same time Mantodea order members except larva and eggs feed pest imagoes too. Moreover the most quantity from these insects corresponds to Coleoptera order (42.6%), next Hemiptera one (37.8%), after that Neuroptera order (15.4%) and the least quantity corresponds to Mantodea one (4.2%). There 15 members of parasite insects entering to 4 families and 2 orders have been defined from theirs Encyrtidae family parasites feed only eggs, *Ichneumonidae* family members feed larva and imagoes and others feed only larva of mulberry pyralids. Analysis of percentage composition of parasites showed that here the most fraction *corresponds* to Braconi*dae* family *(42.6%)*, next to *Ichneumonidae one (37.8%)*, after to Tachinidae*family (15.4%) and the least fraction to* Encyrtidae one *(4.2%)*.

Keywords
mulberrypyralid, predatory enemies, parasite enemies, ecological factors, mulberry tree, fertility, survivability

Introduction

Every year to cultivating agrarian and forest fields of Uzbekistan the several external quarantine insects are invading part of which damage not essential or for them the fight methods constructed and prepared previously. However, there are some insects which after invading mediocre or directly had damaged essentially to the agricultural plants crops.

Literature Review

One of such the most important quarantine insects (before 1993) and at present did been the most dangerous pest of agrarian cultures of Uzbekistan is mulberry pyralid (*Glyphodes pyloalis* Walker) [1]. Because of this pest feeding on the mulberry tree (*Morus alba*) leaves in time for the season gives up to 6-7 generations it causes damage seriously to feed base of silkworms (*Bombyx mori*)decreasing the volume from silkworms cocoons crop and reduces noticeable textile production of Uzbekistan.

Since the registration moment by Walker, 1859 [2]up to 1993 mulberry pyralid showed itself as major pest of mulberry tree also in other countries: China [3], India[4-6], Japan[7-10], and furtherGeorgia[11], Azerbaijan[12], Tajikistan[13], Turkmenistan[14]and Russia[15].

Namely, therefore to investigations on fight against of mulberry pyralid the particular attention had been paid and the many methods had been constructed. It should be here noted that most applied insecticides [6, 9, 10], sex pheromone traps [16, 17] gave the essential results on their efficiency.

Along with them in Uzbekistan since the appearance of this pest the investigations on construction and application of the effective fight methods against of mulberry pyralid had been began too. For example, the investigations on revealing the pest biological features, its distribution [1], application and generation of entomophages [17] had been carried out.

In continuing these type investigations in the own ancient papers we had studied the efficiency of using known in advance entomophages as lacewing (*Chrysopidae carnea*) (the reached biological efficiency up to 85%) [18, 19], bracon(*Bracon hebetor*) (the reached biological efficiency up to 79%)[20, 21], trichogrammas*TrichogrammaEvanescens Westwood* (the reached biological efficiency up to 52%)[22] and its other kinds (the reached biological efficiency up to 67%) [23], flies taxine specie (*Goniacilipera Rd*.)*Tachinidae* family (the reached biological efficiency up to 67%)[24], using of microbiological preparations “Naturalis L” (the reached biological efficiency up to 78%) [25], “Prestige” Bayer firm (the reached biological efficiency up to 75%) [26], and alsoAshersonia mushrooms (the reached biological efficiency up to 80%)[27]. We had revealed the role of the trapping belt (damage decreasing the mulberry pyralid leaves up to 67%) [28] and had investigated the food specificity of mulberry pyralid too (it turned out the most preferred food is *MorusBombysis* specie of mulberry tree) [29]. Moreover efficiency of using chemical preparations, “Avaunt” producing by “Dupon” firm (United States) and “Alexander” producing “ParidjatAdsensis” firm (India) and also their influence to mulberry pyralidentomophages on simultaneously using ones together with these entomophages (the reached biological efficiency up to 80%) had been studied [30].

It is known that today the first place on protection of mulberry tree from mulberry pyralid occupies development of such fight methods against of the pest, which, on the one hand, control the mulberry pyralid quantity, and the other hand, do not cause the serious damage to the mulberry tree, cocoon silkworms, environment, ground, water and workers of agrarian branch. In a word the actual task of modern science on the plants protection is construction of ecological pure fight methods against of mulberry pyralid. Undoubtedly, here the leading place will take the biological fight method in which for fight against of pest its natural enemies – entomophages are used.

Despite the fact that still essential investigations had been carried out the systematization of natural enemies of mulberry pyralid in Uzbekistan had not been done yet. Without detail studying of order and family composition of predatory and parasite insects it is impossible to finish the construction of complex fight method against of mulberry pyralid that is protection of mulberry tree using nontoxic methods.

In present paper the analysis results of investigations on mulberry pyralid development and revealing the classification order and family compositions its natural enemies in the Andijan district climatic conditions has been presented.

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Methods

The objects of our investigations were the different mulberry pyralid development stages and its natural enemies – predatory and parasite entomophages, which can be seen in period of the total season in mulberry tree gardens of Andijan district. Experiences in three stages have been carried out. On the first stage in the laboratory conditions, we studied the vitality of mulberry pyralid to the ecological factors changes. The second stage investigations directly in the field conditions have been carried out. There we studied the dynamics of change of mulberry piralid butterflies and larva quantities and also mulberry tree leaves damage from mulberry pyralid in comparison of 2016 and 2017 years seasons. On the finishing third stage of carried out investigations we made classification of order, family and species compositions of mulberry pyralid natural enemies.

In experiences butterflies quantity on tree $N_{\text{butterflies}}$ we calculated by representations

$$N_{\text{butterflies}} = \sum_{i=1}^{n} n_{\text{butterflies}}\ , \tag{1}$$

$$< N_{\text{butterflies}} >= \frac{N_{\text{butterflies}}}{n}\ , \tag{2}$$

here $n_{\text{butterflies}}$ is the butterflies quantity which caught to a pheromone trap in period of concrete month, i is the pheromone trap serial number, n is the quantity pheromone traps themselves and $<N_{\text{butterflies}}>$ is the average of butterflies quantity which caught to a pheromone trap in period of a month.

Larva quantity on a tree N_{larva} we defined on these trees where pheromone traps were hanged on branches and trees quantities by representations

$$N_{\text{larva}} = \sum_{j=1}^{m} n_{\text{larva}}\ , \tag{3}$$

$$< N_{\text{larva}} >= \frac{N_{\text{larva}}}{m}\ , \tag{4}$$

heren_{larva} is the larva quantity detected in period of concrete month, j is the branches serial number on the concrete tree, m is the trees quantity and $<N_{\text{larva}}>$ average of larva quantity detected for a month on a tree.

In order to define the damaging degree of trees from mulberry pyralid larva on distances about 800-900 meters from installed pheromone traps mulberry trees we chose other separate mulberry trees as control. In order to facilitate calculations we separated such mulberry trees, which before the experiences have approximately simultaneously width and height. In order to avoid the appearance of mulberry pyralid after collecting silkworm cocoons (from end of May up to begin June) on these trees we processed with chemical preparation “Karate” having the second toxic degree. Mulberry leaves damaging degree from mulberry pyralid larva DD we defined by representation

$$DD = \frac{Ba - Ab}{Aa} \cdot 100\%\ , \tag{5}$$

here$A$ and a are the healthy leaves quantities on control before and after finishing of a concrete month, correspondingly, B and b are the same ones for that trees to which the pheromone traps were hung.

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The first stage experiences in the laboratory of plants protection department of Tashkent state agrarian university in period of 2016-2018 years seasons since April up to end of October lasting 7 months have been carried out. While we studied influence of ecological factors to generations in period of a season and food process of mulberry pyralid. In order to do this first from the damaged by mulberry pyralid mulberry ranks for laboratory samples we collected 2-3 stages pest larva. These samples were grew in the special laboratory conditions by temperature $25^{o}C$ and moisture 55-60%. In order to keep the temperature constant we used MEMMEPTthermostat. 254pieces of mulberry pyralid larva to glass jars on 10 pieces have been decomposed. Two twice in everyday we put to jars fresh and young mulberry tree leaves. Then larva turned to pupae from which after that 74 butterflies hatched out. Next, these butterflies shifted to separate jars to that in result in the each jar were one female and one male. After the jars on four variants and kept at temperatures 15, 25, 35 and $45^{o}C$ have been divided. The air moisture in the each variants according to chosen temperatures has been changed. The aim of investigations was to study the dependence of butterflies fertility and vitality on the temperature.

As experiences shown that the butterflies begin to lay eggs after 3-4 days after their appearance from pupae. First they lay on 4-5 pieces, after on 7-8 pieces and in finishing periods of own life one put on 2-3 pieces eggs. These eggs for future steps of first investigations stage have been separated.

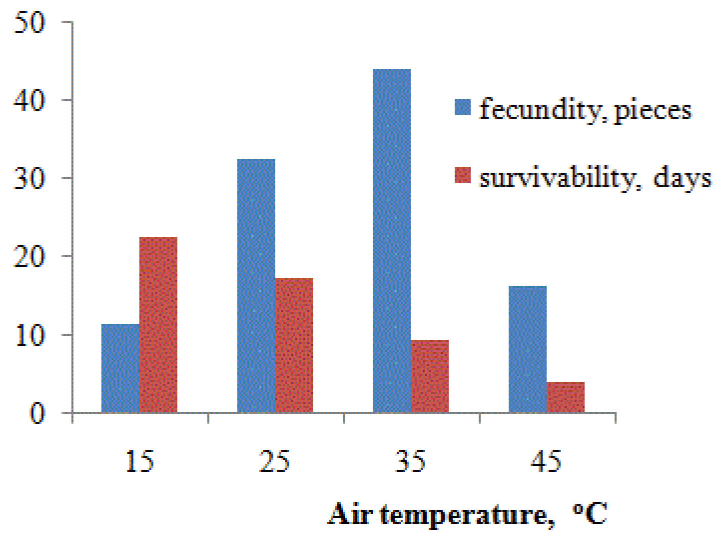

Figure 1. Influence of environment temperature to fertility (blue bars) and vitality (red bars) of mulberry pyralid butterflies

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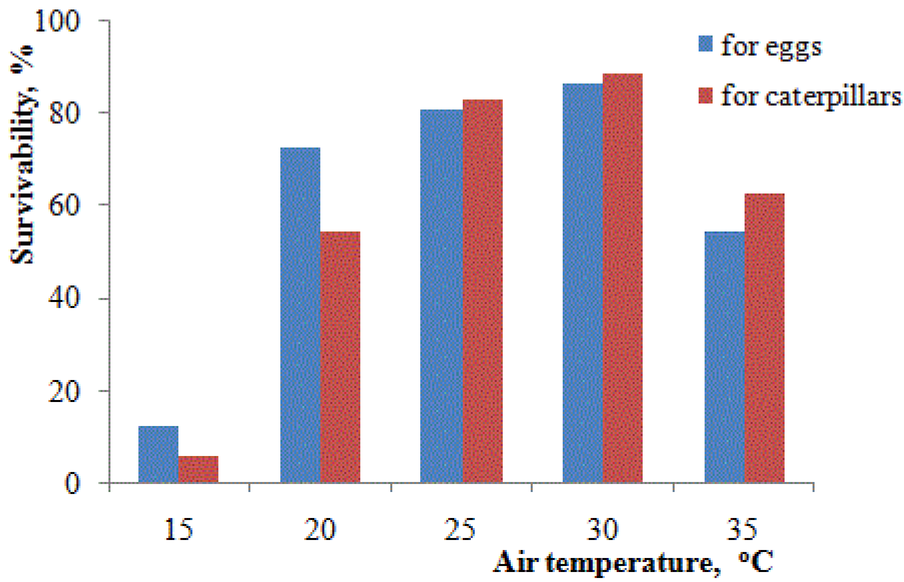

Figure 2. Influence of environment temperature to fertility of eggs (blue bars) and larva (red bars) of mulberry pyralid

For these experiences we had selected the mulberry trees situated on the defenses along the cotton fields. Quantity of selected mulberry trees was on 10 trees in which the eggs, larva and imagoes were registered. The larva quantity and damaging degree we have calculated by Dospekhov method. The pheromone traps were hanged to 3 trees from selected for experiences mulberry trees both as in 2016 and as 2017.

As experiences showed the first trapped butterflies in 2016 in the first decade of May and in 2017 in the first decade of April have been observed. The average population degrees of mulberry pyralid butterflies and larva and damaged themselves mulberry trees for 2016 and 2017 seasons have been presented in Figures 3-4. It seen from that figures both as in 2016 and as 2017 the butterflies quantities were approximately equally (on 8 and 9 pieces, accordingly). However, in June of 2016 we observed growing the butterfly quantity (14 pieces) which in practical contradiction with the 2017 analogical degree (3 pieces). The same difference up to end of corresponding seasons has been observed too.

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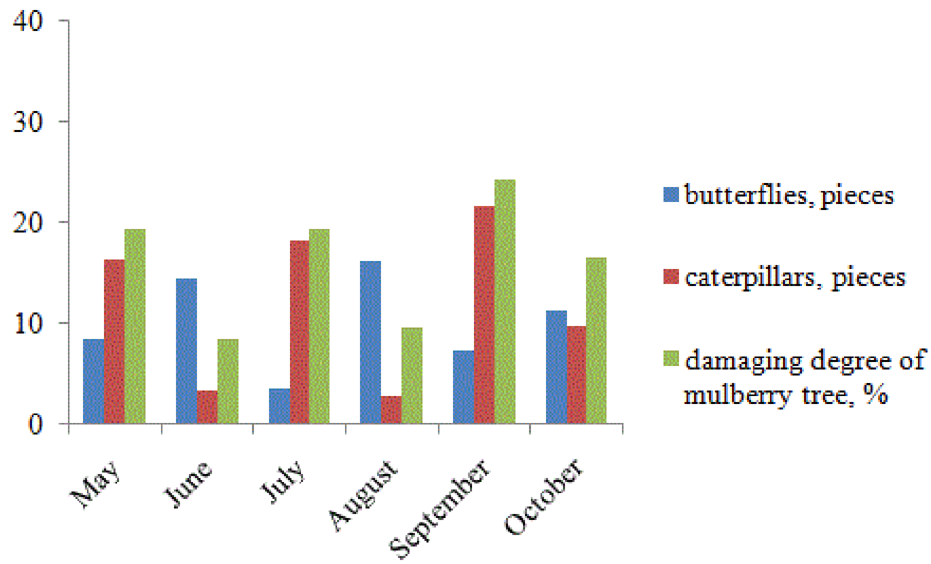

Figure 3. Population averages of butterflies (blue bars) and larva (red bars) of mulberry pyralid and damage form them mulberry tree (green bars) for 2016 season

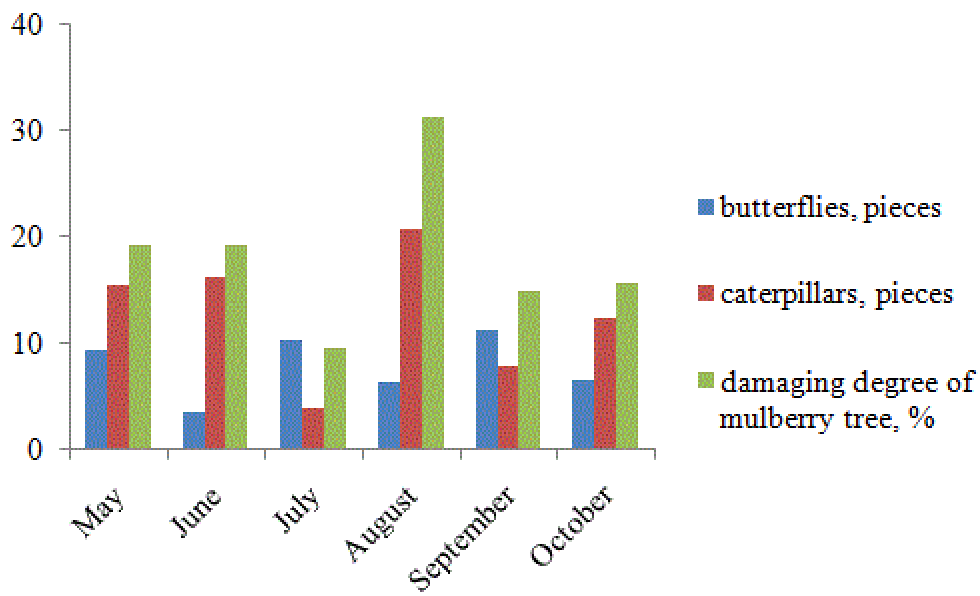

Figure 4. Population averages of butterflies (blue bars) and larva (red bars) of mulberry pyralid and damage form them mulberry tree (green bars) for 2017 season

As to the mulberry pyralid larva that in both seasons both as decreasing and as increasing their quantities taken place alternately month by month. It should be here noted that the most caterpillar quantity in 2016 have been in September (22 pieces) and the least in August (3 pieces). The analogical degrees for 2017 corresponded to August and July (21 and 4 pieces, correspondingly).

For the tree damaging degrees we have observed decreasing and increasing which taken place alternately month by month too. There the most damage in 2016 we have observed to

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September (24%) and the least to June (8%). The analogical degrees (31% and 9%) to one month at that on the most to month previously and on the least to month later have been shifted.

Results

The first stage

The investigations results of dependence of butterflies fertility and vitality on the temperature have been represented on Figure 1, from which, in particularly, is seen that the least butterflies fertility corresponds to air temperature 15^{o}C and the most to 35^{o}C. The analogical degrees for the life expectancy corresponds to 45^{o}C and 15^{o}C, accordingly. It follows that mulberry pyralid butterflies lay the eggs on the comparative high temperatures. However, on these temperatures the expectancy of being in the butterfly stage is decreasing.

After we investigated the dependence of periods of being in eggs and larva stages on the temperature and observed their development processes too. The aim of these experiences was identification the persistence of the pest different stages to ecological factors changes.

For that the laid eggs together with leaves to the special dishes have been transferred which in thermostats in five variants at temperatures 15^{o}C, 20^{o}C, 25^{o}C, 30^{o}C and 35^{o}C, correspondingly up to hatching larva moment have been maintained. These temperatures values choice is conditioned by that at ones the comparative fertility of mulberry pyralid eggs have been observed (see, Figure 1) and these temperatures are also character for Andijan district climate conditions in the season cultivating periods of agrarian cultures. The results of investigations have been presented on Figure 2. It is seen from the Figure that for mulberry pyralid both as to eggs and as larva hatched from themselves the least vitality corresponds to temperature 15^{o}C as the same time the most one deals with to temperatures 25-30^{o}C.

At end of first stage experiences we had defined the durations of stay in each of the stages (eggs, larva, pupae, imagoes) and also development period for a total generation of mulberry pyralid. This investigation had been carried out in five variants too and same temperatures 15^{o}C, 20^{o}C, 25^{o}C, 30^{o}C and 35^{o}C, correspondingly. Their results on Table 1 have been presented.

Table 1. Durability of staying in different development stages of mulberry pyralid at different environment temperatures*(laboratory experiences, 2016-2018)*

№	Life cycles of mulberry pyralid	Durability of staying in that development stage at different temperatures, *days*				
		15°C	20°C	25°C	30°C	35°C
1.	Eggs period	8,2±0,3	5,8±0,4	4,3±0,6	3,2±0,4	2,8±0,2
2.	Caterpillar period	-	22,5±0,7	15,6±0,3	12,2±0,6	10,3±0,3
3.	Pupae period	-	13,2±0,6	9,1±0,7	6,7±0,5	5,3±0,2
4.	Imago period	-	18,7±0,2	16,7±0,3	12,5±0,6	9,6±0,4
5.	Days quantity for developing one generation	-	60,2±0,5	45,7±0,4	34,6±0,6	28,0±0,2

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It is seen from the Table, in particularly, that the durability of staying in egg stage of mulberry pyralid at environment temperature 15^{o}C equals approximately to 8 days which is decreasing on growing the temperature reaching down to 3 days at temperature 35^{o}C. As to the other developing stages, there for themselves also the decreasing staying period on growing temperature in the same cycles has been observed.

It is easily notices that the required quantity for construction of mulberry pyralid total generation is varies within 28÷60 days, which also decreases on temperature growing.

The second stage

It should be to note here that the real degrees for field conditions can be differ from results presented on Figures 1-2 and Table 1. The cause for this discrepancy deals with in natural conditions the mulberry pyralid larva will accommodate in advance to decreasing and increasing of temperature of environment, which at the laboratory conditions is not observing.

Namely, therefore as continuing investigations further we have carried out the experiences on revealing mulberry pyralid population degree in field conditions of Andijan district in comparison of 2016 and 2017 years seasons. Then we have studied periods of wintering and living of this pest.

These investigations we have carried out in mulberry trees rows of farms of Bo'z (now Bo'ston) and Baliqchi regions of Andijan district. There the first we have observed the mulberry pyralid wintering periods. Since March second half of 2016 after temperature rises up to 22^{o}C we began set the pheromone traps with gauze soaked in solution water with an antioxidant pheromone substance.

The third stage

The aim of finishing third stage of investigations was to reveal the predatory and parasite insects of mulberry pyralid occurring in period of a season in Andijan district climate conditions. The experiences on defining of predatory insects we have carried out from the beginning of the moment when butterflies lay eggs before mulberry tree leaves damaging period and after as observations up to end of 2017 season. We have registered occurred predatory insects the results of which have been presented at Table 2. It is seen from the table that all revealed ourselves 10 insects species entered to 4 families and 4 orders. As observations showed members of *Neuroptera*, *Coleoptera* and *Hemiptera* orders feed basicallythe mulberry pyralid larva and eggs. While *Mantodea* order members except larva and eggs feed pest imago too.

Table 2. Species of predatory entomophages of mulberry pyralid and their systematic analysis*(Andijan district, 2016-2017)*

№	order	family	species	Food stages of mining
1.	*Neuroptera*	*Chrysopidae*	*Chrysopa carnea* Step. *Chrysopaseptempunctata*Wegm.	larva, eggs

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2.	*Coleoptera*	*Coccinellidae*	*Adaliabipunctata*Lin. *Adonia variegata* Gz. *Coccinellaseptempunctata*Lin. *Exochomus flavipes* Thurb. *Coccinellapunctata*Lin.	larva, eggs
3.	*Hemiptera*	*Miridae*	*Lydellanigripes*Fall. *Anastatusdisparis*Rusch.	larva, eggs
4.	*Mantodea*	*Mantidae*	*Mantis religiosa*Lin	larva, eggs, imagoes

Together with that we have analyzed per sent composition occurring on the tree predatory entomophages, results of that have been presented in Figure 5. It is seen from this figure that the most quantity corresponds to *Coleoptera*, after to *Hemiptera*, further to *Neuroptera* and the least to *Mantodea* orders.

In the finishing stage investigations we first collected damaged by natural method mulberry pyralid eggs, larva and butterflies, after separated them to several covered on top with gauze glass jars, maintain them in the natural conditions. Further, a certain time after appearance in the jars other insects orders we have defined the composition of mulberry pyralid enemies by species, families and orders. The analysis results have been presented on Table 3, from which is seen that we have all revealed 15 species of parasite insects entering to 4 families and 2 orders. From ones *Encyrtidae*family parasites feed only eggs, *Ichneumonidae* family feed larva and pupae and others feed only larva of mulberry pyralid.

Table 3. Parasite entomophages species and their systematic analisys
(Andijan district, 2016-2017)

№	order	family	species	Development stage of mining
1.	*Hymenoptera*	*Ichneumonidae*	*Itoplectismaculator*F. *Diadegmaarmilatta*Grav. *Diadegmafenestralis*Holmg. *Scambusbrevicornis*Grav.	larva, pupae
		Braconidae	*Apantelesvitripennis*Hall. *Apantelesxanthostigma* Hal. *Braconhebetor*Say. *Macrocentrus delicatus* Cress. *Ascogasterquadridentata*Wesm. *Microdusrufipes*Nees.	young and adult larva
		Encyrtidae	*Ageniaspisfuscicollis*Dalm.	larva
2.	*Diptera*	*Tachinidae*	*Ernestiarudis*Fll. *Nemorillamaculosa*Mg. *Lydella nigripes* Fall. *Gonia cilipera* Rd.	young and adult larva

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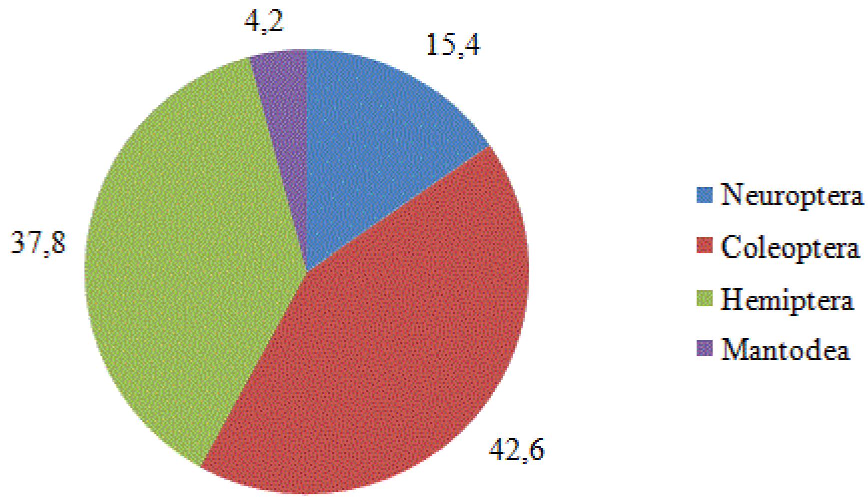

Figure 5. The percentage representation of order composition of predatory entomophages of mulberry pyralid

The analysis of parasites per sent composition has been presented on Figure 6, it is seen from which here the largest share are representative of *Braconidae*, after *Ichneumonidae*, further *Tachinidae* and the least share corresponds to *Encyrtidae* families.

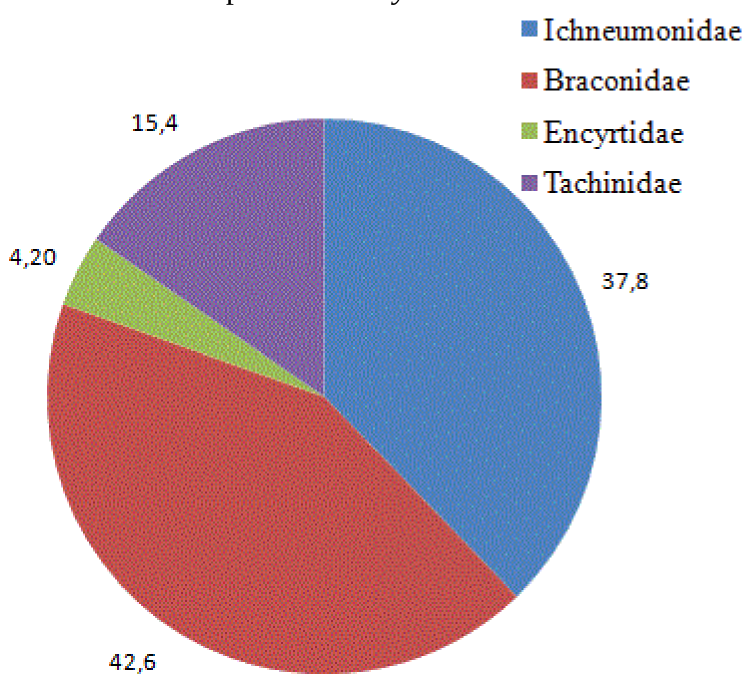

Figure 6. The percentage representation of family composition of parasite entomophages of mulberry pyralid

Conclusion

Thus, based on the experiences results analysis carried out on investigation of mulberry pyralid development and revealing classification of order and family composition of its natural enemies in Andijan district climate conditions we shell list the main points of carried out investigations.
The first, the least butterfly fertility corresponds to air temperature 15^{o}C and the most to 35^{o}C. The analogical degrees for butterfly life expectancy correspond to temperatures 45^{o}C and 15^{o}C. These values testify that mulberry pyralid butterflies lay more eggs in comparative high temperatures. However, their duration of stay in butterfly stage at such temperatures is decreasing.

The second, for both as eggs and as emerging from them larva of mulberry pyralid the least vitality corresponds to temperature 15^{o}C at the same time the most one observes to temperature 25-30^{o}C. Other words, the duration of stay in eggs stage of mulberry pyralid at environment temperature 15^{o}C equals approximately to 8 days which on increasing temperature is decreasing reaching down to 3 days at temperature 35^{o}C. As to the other development stages for them the decreasing staying periods in these cycles on growing temperature have been observed too. For creating mulberry pyralid one total generation requires 28÷60 days and this period on increasing of the temperature is decreasing too.

The third, the damaging comparative analysis of mulberry tree rows of 2016 and 2017 showed that the most damaging degree of trees in 2016 we observed in September (24%) and the least one in June (8%). In 2017 the analogical values (31% and 9%) to one month were removed, moreover the most value to one month before and the least after one month were removed.

In fourth, from the natural enemies inhabited in Andijan district climate conditions 10 species of predatory insects entering to 4 families and 4 orders have been revealed. From ones *Neuroptera*, *Coleoptera* and *Hemiptera* species feed, in basically, mulberry pyralid larva and eggs as the same time *Mantodea* species members except larva and eggs feed the pest imagoes too. Moreover, from these insects the most quantity corresponds to *Coleoptera* (42.6%), after *Hemiptera* (37.8%), further *Neuroptera* (15.4%) and the least to *Mantodea*(4.2%) species.

In fifth, from parasite insects we have revealed all 15 species entering to 4 families and 2 orders, from them *Encyrtidae* family parasites feeds only eggs, *Ichneumonidae* family feeds larva and pupae, other families feed only larva of mulberry pyralid. The analysis of the percentage composition showed that here the largest share correspond to members of *Braconidae*(42.6%), after *Ichneumonidae* (37.8%), further *Tachinidae* (15.4%) and the least *Encyrtidae* (4.2%)families.

The results mentioned above are very important for farmers cultivating silkworm cocoons in fight against the most dangerous today pest of mulberry tree, that is, mulberry pyralid.

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