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Evaluation of transformation of energy in major pest of *Triticum aestivum* in Agra Uttar Pradesh region

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Abstract
Mythimna separate's energy transformation was examined with reference to food consumption, the basis for tissue growth at various instars, assimilation rate, and respiration rate. According to experimental results based on live, dry body weight, a single *Mythimna separata* caterpillar's average daily consumption increased from the first to the sixth instar. More food was devoured by the male caterpillar than the female. Males' metabolic activity was shown to be higher during the Ist, IIIrd, and VIth instar stages than they were during the IInd, IVth, and Vth instar stages. Average values for tissue growth and respiration indicated that as tissue growth grew from the first to the last instar of the caterpillar, so did the average rate of respiration. The consumption of food that promotes the growth of insect pest tissue affects the metabolic rate of the larvae.

Keywords: *Mythimna separata*, larva, *Triticum aestivum*, egestion, respiration, energy transformation

Introduction
In the northern part of India in Uttar Pradesh, *Mythimna separata* is a severe pest of the *Triticum aestivum* / wheat crop (a major cash crop). The goal of the study in this regard was to improve *Triticum aestivum* integrated pest management system. The caterpillar immediately begins feeding on the chlorophyll tissue of the leaf of immature *Triticum aestivum* seedlings after hatching due to its looped crawling activity. As a result, the production of food is harmed, which in turn causes a bigger delay in seed germination and plant growth. So, regardless of the severity of the infestation, farmers continue to use various pesticides.
It may be possible to develop the best management techniques for farmers by studying the bioenergetics of immature *Mythimna separata* (Lepidoptera: Noctuidae). The rate of assimilation and tissue growth of such insect pests will be better understood if the consumption of food is evaluated on a live weight basis.

Material and Method
Mythimna separata stock cultures were developed and kept alive. With the aid of a light trap system, the moths were captured and raised in cages. In a lab setting, the eggs produced in captivity were permitted to hatch. The larvae were kept alive on the host plant and were raised in separate petri dishes (in each case 10 larvae separately male and female). Male and female instars of the *Mythimna separata* larvae were monitored for a progressive rise in body weight as they progressed through the first six weight-based instars. Following a 24-hour feeding period, the leftover food and egesta were collected separately and weighed using an electric pan balance. Three fundamental factors, including the larvae's body weight, consumption, and egestion, were estimated on the basis of live, dry weight.

Assimilation = Consumption – Egestion (At 24 hrs.); Tissue growth = Increase in body weight of the instar during 24 hrs. Respiration = Assimilation - Tissue growth

The detail of experimental materials used, procedures and techniques followed during the course of investigation described in this chapter. Experiments were conducted in the Entomology Research Laboratory, Department of Zoology, Agra College, Agra UP. A stock culture of *Mythimna separata*, *Haworth* was developed and maintain in the entomology laboratory. The adult moths collected jcrmy type light trap were placed in glass chimney then transferred in rearing cages. During captivity the egg laid by females were allowed to hatch under laboratory conditions. The caterpillars were reared in separate petri dishes and were maintained on the host plant (*T. aestivum*). To provide a regular supply of food, *Triticum aestivum* crop was raised in the field and all the agronomic practices were carried out as per the recommendation. The mature larvae were allowed to pupae in the laboratory and the adult moth emerged out from pupae were utilized for further studies. The egg and successive stages of caterpillar and pupae were preserved in a mixture of DKAA (Dioxine, Kerosine, Acetic acid, Absolute alcohol); 1:1:2:7 for 8 hrs, in light and then preserved in 70% alcohol for further studies. The meteorological data on temperature (ºC) and relative humidity (%), were also recorded and correlated with the study of *M. separata*.

The Bachmann's thermometer was used for getting the temperatures unite; the average caloric values of dry weight /milligram were calculated. Such caloric values multiplied with the dry weight values of different instars for getting caloric values of each index parameters like egestion, assimilation, consumption, tissue growth and respiration were calculated on live weight basis, dry weight basis. The assimilation values were obtained directly by subtracting the egesta from ingested food. The consumption of food calculated as the difference between the weight of initial food supply and the weight of remaining plant material after each for 24 hrs of feeding the tissue growth was directly measured as an increase in the body weight of the larvae during 24 hrs period. Rate of respiration was estimated by subtraction of tissue growth from assimilation other parameters belonging to ecological growth efficiency for *Mythimna separata* were calculated by the formula as per below-

Consumption index = Weight of ingested food / Period of feeding (days) × mean weight of animal during feeding period

Growth rate = Wt. gained by animal during feeding period / Duration of feeding (days) × mean weight of animal during feeding period

Efficiency of conversion = Wt. gained by animal during feeding period / Wt. of ingested food of ingested food to body substances × 100

Efficiency of conversion = Wt. gained by animal during feeding period /Wt. of ingested food – Wt. of faeces of ingested food to body substances x 100

Table 1: Number of instars of *M. separata* on *T. aestivum* spikelets with different parameters calculated in mgs /…/ d / on dry weight basis

Instar	Sex	Body weight	Tissue growth	Consumption	Assimilation	Egestion	Respiration
I	M	0.0246±0.0008	0.0565±0.0012	0.6209±0.0088	0.6137±0.0090	0.0072±0.0010	0.5572±0.0078
	F	0.0243±0.0012	0.0450±0.0018	0.6141±0.0097	0.6029±0.0100	0.0112±0.0003	0.5579±0.0082
	A	0.0245±0.0016	0.0508±0.0015	0.6175±0.0089	0.6083±0.0095	0.0092±0.0007	0.5576±0.0080
II	M	0.3005±0.0100	0.2233±0.0090	1.1158±0.0800	0.8150±0.0099	0.3008±0.0701	0.5917±0.0009
	F	0.2649±0.0128	0.2354±0.0078	1.1687±0.0879	1.0115±0.0186	0.1572±0.0693	0.7761±0.0108
	A	0.2827±0.014	0.2294±0.0084	1.1423±0.0839	0.9133±0.0143	0.2290±0.0697	0.6839±0.0059
III	M	1.8619±0.0420	1.0585±0.0289	2.8348±0.0876	1.4019±0.0780	1.4329±0.0096	0.3434±0.0491
	F	1.6775±0.0386	1.0337±0.0318	2.6554±0.1086	1.4683±0.0698	1.1871±0.0388	0.4346±0.0380
	A	1.7697±0.0403	1.0461±0.0299	2.7451±0.0981	1.4351±0.0739	1.3100±0.0232	0.389±0.0436
IV	M	5.9253±0.3898	1.5766±0.0879	8.3944±0.7900	3.3498±0.1865	5.0446±0.6035	1.7732±0.0986
	F	5.6446±0.4208	2.0270±0.0998	8.9400±0.8699	3.7993±0.2085	5.1407±0.6614	1.7723±0.1087
	A	5.7805±0.4049	1.8018±0.0939	8.6672±0.8299	3.5746±0.1975	5.0927±0.6325	1.7728±0.1037
V	M	25.9476±2.97738	12.0043±1.007	19.0755±1.1065	17.8619±1.0897	11.2136±0.0968	5.8576±0.089
	F	23.9506±2.2006	9.8697±0.9876	18.2661±1.9830	17.1386±1.1900	11.1275±0.7930	7.2689±0.2024
	A	24.9491±2.5872	10.9370±0.9973	18.6708±1.5848	7.5003±1.1399	11.1706±0.4449	6.563±0.1457
VI	M	99.8271±7.9098	11.2436±1.9800	48.3056±3.8765	17.7339±1.0890	30.5717±2.27875	6.4903±0.5910
	F	97.6290±6.5580	12.5687±2.003	47.1886±2.9203	16.5943±1.6051	30.5943±1.3152	4.0256±0.3952
	A	98.7281±7.2339	11.9051±1.9915	47.7471±3.3984	17.1641±1.3470	30.5830±2.0514	5.2574±0.4931

M=male, F=Female & A = Average. All values represent mean ± SE

Observation revealed that the body weight of a male caterpillar on dry weight basis throughout its larval period also remain higher than the female being 756.3465 mg for male and 685.2246 mg for female. (Table-12). The per day graphics of dry body weight also observed progressively increasing in both the male and female caterpillars throughout the larval period from 1st to 6th instar, except the last 3 days when the caterpillar enter into the prepupal stage.

Results

The caterpillar of *Mythimna separate* accumulate 0.2560±0.0139 cal / individual / day at 1st instar and 590.51±14.0956 cal / ind / day at the last instar**.** In all the six instars male carrier excessive calories over the female. (Table-11). It has further being analyzed that an individual throughout its larval span of 15 days achieved 4301.4399 cal from 400.71 mg of dry food consumed by the caterpillar (Table-12). The male with higher calories proved to be better herbivorous than the female in the food chain, 4526.9758 cal and 4075.9038 cal respectively (Table-12). The per day graphics of body weight or energy basis in both, the male and female, followed similar trend as described for body weight on live and dry weight basis.

Tissue growth

As the development proceed, the tissue growth of noctuid depend on temperature and precipitation, on presence or absence of autumn- winter period and upon condition of larval feeding. The tissue growth successively increased from 1st to 6th instar, the average value of tissue growth of an individual caterpillar remain 0.0833±0.02055 mg / day during the 1st instar and 58.2600±10.8696 mg / ind / D, during the last instar on live weight basis. In tissue growth a male larva was observed superior over the female in succeeding instars with an exception of 6th instar where the female is superior than male (63.8887±13.9262) and 52.6266±8.81305 mg / ind / D respectively (Table-9).

The total tissue growth through the larval span by an individual caterpillar has been 21.25% of consumption and 30.10% of assimilation on an average live weight basis (Table-12).

Almost negligible values of tissue growth observed prior to each moult in both male and female are due to corresponding low level of feeding, after casting off its exuviae in each moult, the caterpillar feeds vigorously and attains the peak value on 1st and 2nd day of successive instar stage., however approaching the prepupal stage the tissue growth have been observed below a recognizable limit in both the sexes. A successive increase in tissue growth from 1st to 6th in star was observed dry weight basis taken together the 1st and 2nd instar values of tissue growth suddenly jumped in 3rd and 4th instar which is in turn again erupted to the maximum in 5th and 6th instar (0.0507±0.0015) and (11.9052±1. 9915 mg / ind / D in 1st and 6th instar respectively (Table-1) (Figure- 30). The male caterpillar had shown a better tissue growth at 1st, 3rd and 5th instars (0.0565±0.0013, 0.0585±0.0289 and 12.0042±1.007 mg / ind / D), respectively than a female (Table-1). Significantly, the female caterpillar in its total larval span has much better tissue growth (125.5300 mg) than the male (99.1681 mg) on an average dry weight basis. It has further being observed that the tissue growth has been 13.60%of food consumed per individual throughout ots larval period; with female having much better values (33.40%) than the male (23.50%) (Table 12). The per day graphic representation of tissue growth follow almost the each pattern as for live weight basis. the net productivity in the form of tissue growth carries 0.2005±0.0078 to 56.7695±2.2000 cal / ind / D from 1st to last instar larvae of an average (Table-13).Where the male larva shows better growth at 1st, 5th and 6th instar (0.2145±0.0109, 47.2878±2.0880 and 63.1665±2.6895 cal / ind / D respectively over the female one. The female remain superior at remaining 2nd, 3rd and 4th instars (1.2618 ± 0.0897, 6.0396±0.2999 and 14.1017±1.0068 cal / ind / D) respectively. The total tissue growth shown by an individual caterpillar throughout its larval span was recorded 5-8.0190 and 3 4.27% of consumed food, the female has better tissue growth (36.22% of consumption over the male 32.88% of consumption) (Table-12). The tissue growth curve shows almost parallel graphics in first three instars with peak growth in the middle of 4th and 5th instars, however with peak values in the earlier days of 6th instar in both, the male and female larva.

Table 2: Number of instars and respective stadial period of *Mythimna separata* on *Triticum aestivum* with different parameters calculated in mgs / ind / d on live weight basis

Instar	Sex	Stadial period	Body weight	Tissue growth	Consumption	Egestion	Assimilation	Respiration
I	M	3.7000±0.0000	0.2676±0.0414	0.0892±0.0225	5.3465±0.9103	0.0166±.0588	5.3299±0.9691	5.1468±0.8000
	F	3.7000±0.0000	0.2324±0.0284	0.0774±0.0186	5.2417±0.8162	0.0175±0.0024	5.2242±0.8186	5.0247±0.9466
	A	3.7000±0.0000	0.2500±0.03625	0.0833±0.02055	5.2941±.8632	0.0171±0.0305	5.2770±0.8938	5.08575±0.8733
II	M	2.8000±0.0000	2.6631±0.3689	0.8877±0.1847	7.9854±0.8051	0.1727±0.0167	7.8127±0.7884	6.3001±0.6774
	F	2.7000±0.0000	2.5483±0.3144	0.8494±0.1547	8.3082±83.75	0.1587±0.0054	8.1495±0.8321	6.9250±0.6037
	A	2.8000±0.0000	2.6057±0.34165	0.8685±0.1697	8.1699±42.2775	0.1647±0.01105	7.9811±0.81025	5.1468±0.8000
III	M	2.0000±0.0000	14.0135±1.68731	7.0067±1.0242	18.0541±1.82371	0.7083±0.0238	17.3458±1.79991	10.3391±0.7757
	F	2.0000±0.0000	2.8283±1.2371	6.4141±0.6469	6.6024±1.14631	0.6287±0.0259	15.9737±1.12041	9.5596±0.4735
	A	2.0000±0.0000	3.4209±1.462205	6.7104±0.83555	7.2245±1.48501	0.6628±0.02485	16.6597±1.46016	9.9494±0.06246
IV	M	3.8000±0.0338	42.5445±5.04834	15.4707±3.744181	48.7749±9.55865	6.0075±0.5301	42.7874±9.02854	27.2967±5.28672
	F	3.7100±0.0443	1.0754±4.88984	7.4030±2.97161	51.1140±8.87365	5.3436±0.5283	45.7704±8.34534	28.3677±5.37372
	A	3.7500±0.03905	1.8099±4.96909	11.4368±3.3578	49.1219±9.21615	5.6231±0.5292	44.2789±0.68694	27.8322±5.3302
V	M	2.1800±0.0000	157.3998±16.1658113	52.4666±9.52804	136.1371±24.2387	21.1700±0.78491	114.9671±23.453812	58.7415±12.34677
	F	2.1400±0.0000	8.9715±14.252414	46.3238±8.02134	140.2070±21.874814	19.1417±1.50682	115.0065±20.368012	62.5005±13.92587
	A	2.1600±0.0000	8.1956±15.209112	49.3985±8.77469	138.7651±13.05675	20.1558±1.14586	114.7543±21.91091	60.6210±13.1363
VI	M	5.1400±0.4338	349.7571±23.271633	52.6266±8.81305	336.0766±33.345631	125.4833±0.232312	210.5933±33.577919	145.7078±20.651713
	F	4.2100±0.5333	335.7601±16.991734	63.8887±12.9262	318.5700±22.641832	116.9672±0.904012	111.6127±21.737819	118.9861±12.924814
	A	4.6700±0.48355	342.7586±20.131683	58.2600±10.8696	327.32±27.9937	121.2252±0.56816	161.1030±27.6578	132.3469±16.7883

Table 3: Number of instars of *M. separata* on *T. aestivum* spikelets with different parameters calculated in Cal/Ind/d on energy basis

Instar	Sex	Body weight	Tissue growth	Consumption	Assimilation	Egestion	Respiration
I	M	0.2590±0.0184	0.2145±0.0109	2.3984±0.1870	2.3540±0.1988	0.0444±0.1929	2.1395±0.1879
	F	0.2535±0.0200	0.1865±0.0130	2.3988±0.2013	2.2989±0.2008	0.999±0.0005	2.1124±0.1878
	A	0.2562±0.0138	0.2005±0.0078	2.3986±0.1945	2.3265±0.1998	0.0722±0.0967	2.1259±0.1878
II	M	2.5715±0.1111	1.1238±0.0768	4.3823±0.2968	3.3788±0.2890	1.0035±0.0078	2.2556±0.2122
	F	2.4510±0.1386	1.2618±0.0897	4.5571±0.3080	3.5403±0.2002	1.0168±0.1078	2.2785±0.1105
	A	2.5036±0.0996	1.1561±0.0569	4.4774±0.3024	3.4596±0.2446	1.0102±0.0578	2.2671±0.1614
III	M	12.1319±0.9865	6.0260±0.3811	11.9139±0.6987	16.7327±0.3895	5.1812±0.3092	10.7067±0.0084
	F	11.1098±0.8888	6.0396±0.2999	11.0464±0.7890	16.9831±0.3000	4.0633±0.4890	10.9435±0.0001
	A	11.5569±0.6985	6.0298±0.2302	11.4802±0.7439	16.8579±0.3448	4.6223±0.3991	10.8251±0.0043
IV	M	32.6586±2.9802	12.0700±1.0009	28.4900±1.8950	27.4934±1.0001	10.9966±0.8948	15.4234±0.0008
	F	30.5341±2.7111	14.1017±1.0068	29.9590±1.4685	28.8991±1.0600	11.0599±0.4085	14.7974±0.0532
	A	31.9054±1.8906	13.2457±0.6890	29.2245±1.6818	28.1963±1.0301	11.0283±0.6517	15.1104±0.0270
V	M	108.0715±8.7787	47.2878±2.0880	74.2134±3.6850	67.8072±2.8694	33.4062±0.8156	20.5194±0.7814
	F	102.3750±9.2890	43.9981±2.0003	69.9709±4.1188	65.9623±3.0094	34.0086±1.1094	21.9642±1.0091
	A	105.8159±6.8553	45.6653±1.6080	72.0922±3.9019	58.3848±2.9394	33.7074±0.9625	21.2148±0.8953
VI	M	608.3280±20.8008	63.1665±2.6895	180.3142±7.7987	84.9359±3.7753	95.3783±4.0234	21.7694±1.0858
	F	580.6980±17.1987	50.3726±3.0909	180.3462±7.0533	81.7719±3.6895	98.5743±3.3638	31.0393±0.5986
	A	594.5130±14.0956	56.7695±2.2000	18.3302±7.4260	83.3539±3.7324	96.973±3.6983	26.4044±0.8422

M = male, F = Female & A = Average A = Average, All values represent mean ± SE

Table 4: Analysis values of different parameters throughout the larval period/md basis for *M. separate*

Sex and period	Parameter s	Body weight	Time growth	Consumption	Assimilation	Egestion	Respiration
Male	LW	3750.4580	611.4011	2980.9855	2057.2051	933.7804	1445.804
I to VI	DW	756.3464	99.1681	421.9301	154.2750	267.2750	55.1069
22.00 dyas	E	4526.9758	529.7781	1610.9725	741.3428	869.6297	211.5647
Female	LW	3461.5809	600.9953	2667.9071	1969.8719	698.6352	1368.8766
I to VI	DW	685.2246	125.5300	374.6545	13.3851	221.2694	27.8651
21.69 days	E	4075.9038	526.2600	1453.5264	744.2820	709.2448	218.0220
On average e basis	LW	3606.1945	606.1982	2852.8588	2019.7751	833.0837	1413.5769
I to VI	DW	720.7855	112.3490	398.8423	153.8383	245.0040	41.4893
21.84days	E	4301.4398	528.0190	1537.79784	742.7806	795.0178	214.7616

LW = Live weight basis, DW = Dry weight basis & E = Energy basis Live and dry weight values in mgs and energy basis values in calories

It was observed that 71.30% of ingested food has been assimilated by the caterpillar throughout its larval period on an average live weight whereas the male assimilated 68.77% and female 73.83% (Table 4). The curve for daily assimilation by an individual caterpillar lies in close approximation to the consumption curves in both sexes from 1st to 4th instars, however with some lower values of assimilation during 5th and 6th instar. The value of assimilation on dry weight basis remained successively higher on an average (0.6083±0.0095 mg / ind / D at the 1st instar to 17.1641±1.3470 mg / ind / D at the 6th in star. Where in the male caterpillar has been superior at 1st, 5th and 6th instars over the female. The female caterpillar retained superiority at 2nd, 3rd and 4th in stars in assimilating the ingested food (Table 3). A caterpillar in its total larval span assimilated 38.69% of the ingested food on an average where the female assimilates 36.56% and the female 40.83% (Table 4). Furthermore, although the assimilation curve in two sexes correspond to the consumption with peak being a day earlier to moult in first five instars and on the second day of 6th instar, the assimilation curve on dry weight basis is much lower than the consumption curve and does not lie in close approximation, a different observation than the one observed on live weight basis. On caloric basis, each caterpillar assimilates 2.3265 ± 0.1998to 83.3539 ± 3.7324 calories from 1st to last instar where the rate of assimilation remained

Egestion

After assimilating most of consumed food, the egesta is eliminated from the body of the caterpillar, as the development proceed, the amount of egesta successively increases from first to last instar stage in accordance to the consumption. On an average the egesta increases from 0.0171±0.0305 mg / ind / D during 1st instar to 121.2252±0.56816 mg / ind / D during the 6th instar in live weight basis The caterpillar egesta more from 2nd to 5th instar (0.1725±0.0167, 0.7083±0.0238, 6.0075±0.5301 and 21.1700 ±0.7849 mg/ind/D respectively), while the female on 1st and 6thinstar (0.0175±0.0024 and 116.9672±0.904012 mg / ind / D (Table 2).

The total average egetion by a caterpillar through its larval period was observed 32.45% of the food consumed while 45.84% of food assimilated owing to its shorter lrval period (21.69 days) also having comparatively lower value of food consumption than the male, (2667.9071 mg), a female caterpillar egests lesser than male throughout its larval stage, being 698.0352 mg / ind / D and 933.7804 mg / ind / D respectively (Table 4). With poor values of egestion on the day of moult, the curvature shows the peak value of egestion a day earlier to moult up to 5th instar following the trained of consumption and assimilation. Assimilation in both the sexes although 6th instar male larva has peak egestion on its second day and also fluctuates with the consumption and assimilation pattern. The 6th instar female larva observed to have peak value a day later than malei. e. On the third day rather than the second and therefore does not follow curves for consumption and assimilation. Although 2nd, 3rd and 5th instar male caterpillar egest more than female on dry weight basis, during the remaining 1st, 4th and 6thinstar the female larva remain superior in excretion than male, however, on an average, the successive increase in egestion by the caterpillar was recorded from 1st to last instar (0.0092±0.0007 to 30.5830±2.0514 mg / ind / D) (Table 3). Further analysis revealed that on an average dry weight basis an individual caterpillar throughout its larval span (21.84 days) egested 51.58% of food consume (Table 4). The daily dry weight graphic representation for egesta for both sexes followed the curvature trend as illustrated for the live weight basis. Since eliminated from the body of the caterpillar as the waste product of cellular metabolism the egesta is treated by soil microorganism (decomposers abd transformer) and in termed maintained the soil fertility. Higher for the male in 1st, 5th and 6th instars (2.3540±0.1988, 67.8072±2.8694 and 84.9359±3.7753 cal / ind / D, respectively). In the remaining instar of 2nd, 3rd and 4th, female retained the higher rate of assimilation (3.5403 ±0.2002, 16.9831±0.3000 and 28.89910±1.0600 cal / ind / D respectively) (Table 3). Further analysis on assimilation throughout the larval period of the caterpillar shows that 48.62% of consumption is assimilated by a caterpillar. The female larva was observed much efficient in assimilation the calories than the male i.e. 51.21% and 46.02% of ingested food (Table 4). The per day graphics of assimilation on energy basis followed the similar ttrained as observed on dry weight basis. The egesta carries 0.0722±0.09672, 96.9763±3.6938 cal / ind / D from 1st to 6th larval stage on an average where the male caterpillar egests more of calori in 3rd instar (5.1812±0.3092 cal / ind / D and female caterpillar egests more of calories in 1st, 2nd, 4th, 5th and 6th instars (0.0999±0.0005, 1.0168±0.1078, 11.0599±0.4085, 34.0086±1.1094 and 98.5743±3.3638 cal / ind / D respectively than male (Table 3). In graphic representation for daily average value the curves for different parameter quite close with each other in the first three instar in clear differentiation could be made out in the last three instars, however, almost the same pattern of curvatures has described for live weight basis was followed on energy basis egesta to, the curves for 6th in star in both sexes show more fluctuation.

Respiration

Corresponding the stage of development, the caterpillar respire successively higher from 5.1938±0.0857 mg / ind / D at the first instar stage up to the 132.3469±16.1883 mg / ind / D at the 6th instar stage on an average live weight basis**.** The male has higher rate of respiration at 1st, 3rd and 6th instar (5.2407±0.9466, 10.3391±0.7757 and 145.7078±20.1713mg / ind / D respectively whereas the female 2nd, 4th and 5th instar (6.9250±0.6037, 28.3677±5.3737, 62.500±13.9258 mg / ind / D respectively (Table 2). The amount of assimilated food utilize to maintain the body of the caterpillar is considered here in respiration. The male caterpillar utilized 1445.804 mg and 56.18% of ingested food while the female required 1368.8766 mg and 61.11% of consumed food during the respiration throughout their respective larval period (Table 4). Though on an average the rate of respiration increases throughout the larval stage from 0.5576±0.0080 at the 1st instar to 5.2579±0.4931 mg / ind / D at the 6th instar. The male caterpillar respire more in 4th and 6th instar (1.7732±0.0986 and 6.4903±0.5910 mg/ind/D respectively) than the female which required superior in the rate of respiration in 1st, 2nd, 3rd and 5th instar stages having the respective values of 0.5579±0.0082, 0.7761±0.0108, 0.4346±0.0380 and 7.2689±0.2024 mg / ind / D on dry weight basis (Table 3). Its complete larval span an individual caterpillar needs 41.4891 mg and 26.83% of the food consumed. The estimated energy loss on account of respiration has been 2.1259±0.1878 to 26.4044 ₃ 0.8422 cal / ind / D from 1st to 6th in star on an average but more in the male caterpillar at 1st and 4th instar stages. The values being respectively as 2.1395±0.1879 and 15.4234 ± 0.0008 cal/ind/D than the female). In the remaining stage of 2nd, 3rd, 5th and 6th the female caterpillar retained superiority over the male (the respective values being 2.2785±0.1105, 10.9435±0.0001, 21.9642±1.0091 and 31.0393±0.5986 cal / ind / D) (Table 3) (Figure-61-63). On an average it was observed that throughout its larval period 214.7616 calories were lost in the respiring activity (Table 4)

Food consumption

Corresponding to the live body weight the average per day consumption by an individual caterpillar of *Mythimna separata* successively increase from Ith to VIth in star. The male caterpillar consume more food than female during Ith, IIIrd and VIth instar, which indicate the higher metabolic activity in the former than the later, in conformity with Singh *et al.* (1975). The consumption of food during the last two instar has been estimated to be 85- 95% of the total consumption on an average basis. The maximum amount of consumption ofthe last instar, show that a lot of food energy is required for histogenesis, cocoon and future development in the non-feeding stage-pup. The observations in the present study (*Mythimna separata*) are in agreement with the earlier workers Mc. Ginnis and Kasting (1959) [12]; Wald Waver (1968); Schroeder (1972) [14]; Axelsson *et al.* (1975) [1]; Mathavan and Bhaskaran (1975) [16]; Bailly and Mukerjee (1977) [5]; Scriber and Slansky (1981) [23] and Sharma and Tara (1988) [24], Tara and Hussain (2019) [30].

A successive increasing trend of tissue growth from Ist to VIth instar, leading to the maximum at the last instar has been obserbed from the caterpillar of *Mythimna separata* fed over the *Triticum aestivum*.

The study of Kasting and Mc. Ginnis (1959) [12]; Shcroeder (1973) [22]; Mathavan and Pandian (1975) [17]; Bailly and Singh (1977) [6]; Mackey (1978) [15] and Banerjee and Haque (1984) [7] are in accordance to the present investigation. Tara and Hussain (2019) [30] though recorded a successive increase in tissue growth from Ist to VIth instar of a noctuid but observed a greater falls in the value of tissue growth in the Vth instar larvae. However, Mathavan and Pandian (1975) [17] reported that the fluctuation in environmental condition play an important role on the tissue growth. In the present species male caterpillar is superior in tissue growth over the female on live weight and energy basis having maximum tissue growth at the last instar stage whereas on dry weight basis, the last instar female caterpillar suppressed the male and tissue growth. Major amount of assimilated food is utilized in the metabolic process of respiration to support, to growth and maintenance of the body of larva. In *Mythimna separata* the respiration has been observed higher in male larva than the female on live dry weight and energy basis during last two instars. The higher rate of respiration in male caterpillar is perhaps due to more physiological and metabolic activities than the female.

Ecological growth efficiency

The efficiency of conversion of ingested food in *Mythimna separata* successively increase from Ist to IIIrd instars while fluctuated in the alst instar with a sudden decline in the alst instar in both the sexes on live, dry weight and energy basis. Similar study has been made by LM *et al.* (2003), Hail K Shanuag *et al.* (2015) [10] observed low ecological efficiency values in last two instars. Kogan and Cope (1974) [13] reported constant values till Vth instar but observed sudden decline in the VIth in star. B.R Kaushall. K. Vats (1983) [34] observed thegradual increase in E.C.I values from Ist last instars. However, Benerjee and Haque (1984) [7] observed that E.C.I values increase with the age of larva except in VIth instar which show considerable decrease. The decrease in the value of E.C.I at the last instar in general has been due to the last caterpillar preparedness for entering into pupation Pandian, T.J., *et al.* (1986) [35]. Hirastsuk (1920), Evans (1939) [39], M.C, Ginnis and Kasting (1959) [12] and Vats and Kaushal (1980) [31] has considered a gradual decline in E.C.I values, however, several entomologist (Schroder (1971) [25], Baily and Singh (1977) [6] and Mackey (1978) [15] reported that noset pattern could be evolved for E.C.I in their respective studies. In Lepidoptera E.C.I may increase, decrease or show a little change with fluctuation. E.C.D:-The efficiency of conversion of digested food in *Mythimna separata*, like E.C.I, successively increases up to IIIrd in star and fluctuated from IVth to VIth in stars. Similar Observations have also been reported by Mukerjee and Guppy (1970) [19], Latheef and Harcourt (1972) [14], Banerjee and Hock (1984), and Debora Mello da Silva *et al.* (2017) [36], however, Vats and Kaushal (1980) reported that E.C.D decreases from Ist to IVth instars and then show a sudden increasing trend in Vth instar. Sharma and Tara (1988) [24] mentioned a successive increase in E.C.D up to IVth in star while with very high decrease in the Vth instar of a noctuid. Tarekegn fite *et al.* (2018) [29] concluded that the E.C.D value fluctuate during the Ist three days and then gradually increase towards the end of larval stage. The decreasing trend of E.C.D in the last stages of *Mythimna separata* is probably due to the approach of the larva towards the pupation as reported Singh and Chaudhary (1987) [38]. A.D:-For expressing the digestibility of food material earlier workers used terms like coefficient of utilization (Evans 1939) and digestion coefficient of digestibility (Soohoo and Fraenkel 1966) but Wald Dauer 1968 correcting the nomenclatures as approximate digestibility (A.D), the term which has been adopted in the present work. The

Lepidopterous larvae show decling trend of A.D from I[st] to last instars (Mukerjee and Gupta 1970, Vats and Kaushal1980, Banerjee and Haque 1984) [37, 34, 7]. The present observation has not exception to this rule at different gradients for both the sexes. The I[st] and VI[th] in stars larvae feed on the soft parenchymatous tissue of the tender leaf and spike of spikelet whose cells are easily broken and digested, but as the larva grows it start feeding more and more resistance fibrous plants of the leaves, which results into decline A.D in the successive instars. Similar view have been given by Xingfu Jiang *et al.* (2011) [33], Tara and Hussain (2019) [30] resulted and increasing trend of A.D, though fluctuating from I[st] to last instars noctuid larva G.R:-The larva of *Mythimna separata* has been observed with or most during its first three instars (I[st] to III[rd]) which fluctuate in the later IV to VI instar and decline to the minimum in its last instar on an average live weight basis. Almost similar observations have been given by Yue-qiuLIU *et al.* (2018). Further on dry weight caloric basis it reveal that the caterpillar show successive decrease in growth rate up to IV[th] instar and then fluctuates upto VI[th] in star. The minimum growth rate value in the last caterpillar is perhaps, due to the process of histogenesis and histolysis which occur side by side in the larva while entering into the pupal stage. The values for growth rate lie especially due to foliage chewing of the caterpillar as described by Scriber and Slansky (1981) [23]. Paul W. Williams *et al.* (1990) [21] reported that the growth rate with an uniform increase of weight, is independent of the stage of development. Scriber and Slansky (1981) [23] also stated that growth rate may be one of the useful parameter for the preferential feeding amount different diets. Consumption Index:-The consumption index has been observed in perfect decline order from 1[st] to VI[th] instar of *Mythimna separata* as also observed by Paul W. Williams *et al.* (1990) [21]. Wald Bauer (1968) mention that consumption index on live, dry weight and energy basis signifies to different biological meaning. Consumption index at the fresh weight is probably more meaning full measure of behavioral response of the animal against the food whereas, the dry weight consumption index defines a nutritional response. The present study showed that consumption index dry higher than consumption index live in first four instars, but the last two instars showed that consumption index dry was lower than consumption index live. Wald bauer (1968) found consumption index dry always higher than consumption index live, however, Benerjee and Ray (2011) found consumption index live greater than consumption index dry. Debora G Montazano *et al.* (2019) [8] found that the *Striacosta albicosta* feed an artificial diet in a controlled environment. At 26.6 ± 1C, the overall survival rate from neonatal to adult was 36.72%, and the whole developmental time was roughly 110 days. Egg, larval, prepupal, and pupal stage survival rates were, respectively, 75.71, 98.50, 51.78, and 95.10%. The average time between the egg, larval, prepupal, and pupal phases was 4.64 days, followed by 28.20 days, 41.50 days, and 25.91 days, respectively. 92.50% of larvae reached seven instars during the larval stage, while the rest larvae reached six instars. There was no difference in pupal weight between larvae that reached six and seven instars, which had mean growth ratios of 1.60 and 1.47, respectively.

Food energy budget of larvae of *Mythimna separata* indicate that the male consumed and egested more of calories than the female, whereas, The female assimilated more of calories (51.21% of ingested biomass) than the male (48.79% of ingested biomass) throughout its larval stage. Following the consumption and egestion, tissue growth or net production also remained more in the male than the female, this stored energy in the form of tissue growth remain available to the next trophic level. It was also seen that the female larvae of *Mythimna separata* spend more energy in respiration than the male. Kaushal and Vats (1983) [34] observed food energy budget of Lepidoptera larva and found assimilation as six times more than the egesta. Abarah *et al.* (1989) estimated more of the ingested energy converted into egesta than the assimilatory energy in a Lepidopteron caterpillar. The caloric values of the developmental stages, faeces and host plant leaves for *Mythimna separata* fed over leaves over *Triticum aestivum* can be arranged in descending order as below

Larva> Pupa> Adult>host plant> Faeces

The more calories in the larval stage is most probably is due to a more amount of fat in the larva is also reported by Vats and Kaushal (1980) [34].

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