

The effects of caterpillars and Lepidoptera imagos on water-quality at Lake Kis-Balaton

By

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Abstract. Since 1989 we have identified 14 moth and 1 butterfly species whose caterpillars feed on water plants at the Kis-Balaton area (Table 1). In Table 2 we record the live and the abs. dry body weights of these Lepidoptera, as well as their nitrogen contents. These individuals decrease the organic content of the water by the given amounts because their dead carcasses generally do not get back into the water. This process decreases eutrofication. Table 3 presents a compilation - according to our calculations - of the amount of food consumed, the amount of excrement produced, and the nitrogen content of the excrement for the caterpillar of each species discussed. The food consumption, of course, directly decreases the assimilation capacity of plants, but this effect is increased significantly by the damage caused to plants. About 3/4 of the food taken is returned to the water in the form of excrement which decomposes more quickly than dead pieces of plants. In this way, the significant amount of nitrogen contained in excrement increases eutrofication. In our opinion, Lepidoptera - and animals in general - shape the quality of water through such contradictory and complex effects.

In shaping the quality and trophity of waters, animals - beside plants - naturally play a significant role. This role, however, is only understood in certain of its aspects, and is known and studied primarily with respect to birds. This is shown, for example, by the great interest expressed in 1991 at an international conference dealing with similar issues, in Sackville, Canada. Much less is known in the given topic about insects, even though insects, because of the extra large number of their species and the significant size of their biomass, play a key role in shaping the productional aspects of aquatic life systems. Therefore, we think there is great need for research in this direction, and if we desire to understand and shape the aquatic interrelations of the Kis-Balaton, we cannot ignore the role of insects in this respect.

Previously, we have studied the role of dragonflies, as well as various birds, in the Kis-Balaton area (ANDRIKOVICS and GERE, 1992). In this study, we describe some of our findings of research conducted on lepidoptera. This populous order of animals has many members in close connection with water because their caterpillars (larvae) feed on water plants.

We can analyze the role of Lepidoptera and caterpillars in an aquatic ecosystem from a production-biological - as well as theoretical - viewpoint by a double approach.

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On the one hand, we have to understand the qualitative and quantitative aspects of the courses of matter (and energy) that develop through the metabolism of animals. This way, we can acquaint ourselves with the amount of food consumed by the animals, which in the given case tells us how much assimilating biomass they extract directly from the system, with the amount and destination of the excrement produced, and with their nitrogen treatment, which is of special interest from the standpoint of eutrofication. On the other hand, we have to keep in mind that these and other similar questions only partially explain the functioning of animals. Because of the extra damage inflicted by the ways of feeding, chewing, and finding suitable abodes, most animals that feed on live plants take a much higher toll on the vegetation than what they directly consume. This is especially true for caterpillars feeding on water plants because most of them live inside the plants they eat, sometimes close to the root, making the effects of their chewing felt throughout the plant. Sometimes this causes the death of the plant. The magnitude of these effects can only be estimated by repeated observations of the affected plants. Much valuable information on this topic can be found in the volume edited by VÁSÁRHELYI (1995). Our own examinations and the topic of this paper are concentrated not on this second, but on the first problem mentioned.

Methods

Since 1989 we have systematically studied the Lepidoptera fauna of the Kis-Balaton, especially around Hévízi Channel and Diás Island, by collections during daytime and at nighttime (with the help of lights). We have determined the average live body weight of the various species feeding on water plants by measuring 10 individuals of each species (except in the case of two species that occurred in very scarce numbers). In some cases, especially for species showing high sexual dimorphism, we have made separate measurements for the male and the female. In the case of six individuals of different species (in some cases separately for the two sexes), we have determined the water content and the dry matter content, by the method of drying the specimen at 104 C° until a constant weight was reached. We have considered the water content of the other species to be the same as the species closest to them, because experience shows that it is possible to determine types in this case (GERE, 1979). We have estimated the total quantity of food produced and the food-excrement ratio based on examinations on *Hyphantria cunea* (BALOGH and GERE, 1953; GERE, 1954-56, 1957; NAGY, 1952; JASIČ and MACKO, 1961), on *Phytometra gamma* (SYLVÉN, 1947), on *Lymantria dispar* (LEONARD, 1974; GERE, manuscript), and on *Inachis io* (GERE, manuscript). The nitrogen content of the excrement of Lepidoptera and caterpillars was estimated based on examinations using the halfmicro method of KJELDAHL (BALOGH and GERE, 1953; GERE, 1993) by making use of tipifying.

Results

We have collected 15 species of Lepidoptera in the Kis-Balaton area whose caterpillars feed on water plants or similar food most of the time (Table 1). We note that

Table 1. The species found and their feeding habits

Species and family	The feeding habit of the caterpillar
<i>Phragmataecia castaneae</i> HÜBNER (Cossidae)	1.2.5. In the stem of reed (<i>Phragmites communis</i>)
<i>Chilo phragmitella</i> HÜBNER (Pyralidae or Crambidae)	4.5 In the stem of reed (<i>Phragmites communis</i>) and water mannagrass (<i>Glyceria maxima</i>)
<i>Calamotropha paludella</i> HÜBNER (Pyralidae or Crambidae)	4. On the leaves of bulrush (<i>Typha angustifolia</i> and <i>latifolia</i>)
<i>Scirpophaga praelata</i> SCOPOLI (Pyralidae or Crambidae)	4. On various species of rush (<i>Schoenoplectus species</i>)
<i>Schoenobius gigantellus</i> DENIS & SCHIFFERMÜLLER (Pyralidae or Crambidae)	4. In the stem of reed (<i>Phragmites communis</i>) 5. In the stem of reed (<i>Phragmites communis</i>) and on water mannagrass (<i>Glyceria maxima</i>)
<i>Lycæna dispar</i> HAWORTH (Lycænidae)	2. On the leaves of various dock species (<i>Rumex hydrolapathum</i> and other species)
<i>Philudoria potatoria</i> L. (Lasiocampidae)	2. Among others, on reed (<i>Phragmites communis</i>) and sedge species (<i>Carex</i>) 5. In autumn: on grass, in spring: on sedge (<i>Carex</i>), later on the leaves of reed (<i>Phragmites communis</i>)
<i>Laelia coenosa</i> Hübner (Lymantriidae)	2. Among others, on reed (<i>Phragmites communis</i>) and on the leaves of a sedge species (<i>Cladium mariscus</i>), great bulrush (<i>Schoenoplectus lacustris</i>), water mannagrass (<i>Glyceria maxima</i>) 5. On the leaves of reed (<i>Phragmites communis</i>)
<i>Senta stenoptera</i> STGR. (or <i>flammea</i> CURT.) (Noctuidae)	2. <i>S. flammea</i> : on reed (<i>Phragmites communis</i>) 3. The living style of <i>S. stenoptera</i> 's caterpillar is not yet described 5. Feeds only on reed (<i>Phragmites communis</i>), in the stem or among closed up leaves
<i>Mythimna straminea</i> TREITSCHKE (Noctuidae)	2. On the leaves of reed (<i>Phragmites communis</i>) 5. In spring: on the young shoots, later in the stem
<i>Mythimna pudorina</i> DENIS & SCHIFFERMÜLLER (Noctuidae)	2.3. In autumn: on the leaves of reed (<i>Phragmites communis</i>), after living through the winter: among marsh grasses. 5. After living through the winter, also feeds on the leaves of of reed (<i>Phragmites communis</i>)
<i>Sedina buettneri</i> HERING (Noctuidae)	2. First, mining in the leaves of sedge (<i>Carex acutiformis</i>) and watermannagrass (<i>Glyceria maxima</i>), later in thier stem 3. In the ground, close to the root
<i>Nonagria typhae</i> THUNBERG (Noctuidae)	1. In the stem of bulrush (<i>Typha</i>) 2. On bulrush (<i>Typha angustifolia</i> and <i>latifolia</i>) and on great bulrush (<i>Schoenoplectus lacustris</i>) 3. In the stem and on the fruit of the above
<i>Rhizedra lutosa</i> HÜBNER (Noctuidae)	2.3. In the stem of reed (<i>Phragmites communis</i>) and close to its root
<i>Chilodes maritinus</i> TAUSCHER (Noctuidae)	2. In the stem of reed (<i>Phragmites communis</i>) 3. In its last phase of larva, it feeds on other larvae living in the stem of reed (<i>Phragmites communis</i>)

1. ABAFI-AIGNER, 1907; 2. KOCH, 1988; FORSTER, 1980; 4. GOZMÁNY, 1963; 5. VASÁRHELYI, 1995.

Table 2. The body weight and nitrogen content of the moths and butterflies

Species	Sex	The live weight of one imago (mg)	The abs. dry weight of one imago (mg)	The total nitrogen content of one imago (mg)
<i>Phragmataecia castaneae</i>	male	187.6	69.4	7.9
	female	455.2	141.1	16.1
<i>Chilo phragmitella</i>	mixed	73.9	28.1	3.2
<i>Calamotropha paludella</i>	mixed	70.5	26.8	3.1
<i>Scirpophaga praelata</i>	mixed	60.5	23.0	2.6
<i>Schoenobius gigantellus</i>	male	148.7	58.0	6.6
	female	138.9	48.6	5.5
<i>Lycaena dispar</i>	mixed	76.2	28.9	3.0
<i>Philudoria potatoria</i>	male	348.1	132.3	15.1
	female	797.6	271.2	30.9
<i>Laelia coenosa</i>	male	149.2	55.2	6.3
	female	367.3	110.2	12.6
<i>Senta stenoptera (flammea)</i>	mixed	33.9	12.9	1.4
<i>Mythimna straminea</i>	mixed	97.1	36.9	3.9
<i>Mythimna pudorina</i>	mixed	116.3	44.2	4.6
<i>Sedina buettneri</i>	mixed	130.8	49.7	5.2
<i>Nonagria typhae</i>	mixed	365.5	138.9	14.6
<i>Rhizedra lutosa</i>	mixed	435.8	165.6	17.4
<i>Chilodes maritinus</i>	mixed	38.7	14.7	1.5

Table 3. The production biological parameters of the caterpillars

Species	Sex	The amount of food consumed by one caterpillar	The total excrement of one caterpillar	The total nitrogen content in the excrement of one caterpillar (mg)
Given as abs. dry weight (mg)				
<i>Phragmataecia castaneae</i>	male	1617	1208	20,5
	female	3262	2455	41,7
<i>Chilo phragmitella</i>	mixed	654	489	8,3
<i>Calamotropha paludella</i>	mixed	624	466	7,9
<i>Scirpophaga praelata</i>	mixed	536	400	6,8
<i>Schoenobius gigantellus</i>	male	1351	1009	17,2
	female	846	846	14,4
<i>Lycaena dispar</i>	mixed	673	503	8,5
<i>Philudoria potatoria</i>	male	3083	2302	39,1
	female	6319	4719	80,2
<i>Laelia coenosa</i>	male	1286	961	16,3
	female	2568	1918	32,6
<i>Senta stenoptera (flammea)</i>	mixed	301	225	3,8
<i>Mythimna straminea</i>	mixed	860	642	10,9
<i>Mythimna pudorina</i>	mixed	1030	769	13,1
<i>Sedina buettneri</i>	mixed	1158	865	14,7
<i>Nonagria typhae</i>	mixed	3236	2417	41,1
<i>Rhizedra lutosa</i>	mixed	3858	2881	49,0
<i>Chilodes maritinus</i>	mixed	342	256	4,3

we use LERAUT's (1980) nomenclature. *Lycaena dispar* occurred only once or twice. *Senta stenoptera* is arguably not an independent species; according to some researchers, it is the second generation of the morphologically similar *S. flamma* (VÁSÁRHELYI, 1995). In Table 1 we report the feeding habits and plants consumed by the caterpillars according to the literature.

Most of the species occurred regularly in the area every year, with the most frequent species being *Ph. castaneae*, *Ch. phragmitella*, *Sch. gigantellus*, *Ph. potatoia*, *L. coenosa*, *M. straminea*, *N. typhae*, and *Rh. lutosa*. FISCHL has noticed damage caused by *Ch. phragmitella* on reed (*Phragmites communis*), bulrush (especially *T. latifolia*), and on horsetail (*Equisetum*). The caterpillars primarily chewed these plants at the water level (oral communication).

Table 2 reports the live and the abs. dry body weight of the moths and the butterflies. The individual animals take at least this much matter out of the water. Moreover, since most of them do not die above the water, and since the non-feeding species live up most of this matter (GERE, 1964), the matter taken out of the water generally does not get back into it. The table also gives information about the nitrogen contents of the Lepidoptera. It can be observed that, for example, 1253 (young) female *Ph. potatoia* amount to one kilogram of biomass. (With regard to the number of individual Lepidoptera, this is not a large number.) Further, 32362 female *Ph. potatoia* contain one kilogram of nitrogen, which is also derived from the water.

With respect to these observations, the effect of Lepidoptera can be said to work definitely against eutrofication. And, considering all the various species given in the table, and other species that might be found later on, this effect is not at all negligible.

The effects of the caterpillars, by their feeding and metabolism, are more complex. Table 3 shows the amount of food consumed by the larvae and the amount of excrement produced.

Continuing with the example of *Ph. potatoia*, it can be calculated that 396 individual caterpillars consume a total of one kilogram plant matter (assuming 75% water content for the plants). Therefore, they decrease the amount of the vegetation biomass by at least this much. But it must be emphasized once again that because of other damage caused to the plants, the total effects of obstructing the development of vegetation are much larger. The interrelations between the quality of water and the aquatic vegetation are much researched and evaluated; therefore, we will not deal with the question in its details.

The amount of excrement produced by caterpillars feeding on green plants usually adds up to about 74-75% (of the abs. dry matter) of the total weight of food consumed. The excrement of the caterpillars feeding on water plants generally gets back into the water, not far from the place of feeding. In this way, these individuals generally decrease the amount of organic matter in the water by about 1/4 of the total amount of plant consumed. The large amount of excrement getting into the water; however, has very different effects from the same amount of dead plant parts. First of all, it must be known that the excrement is a biologically important source of nutriment. The energy content of the food of *Hyphantria cunea* caterpillars is 4380 cal/g (of the abs. dry weight), and the same figure for their excrement is not much lower, 4000-4200 cal, depending on the age of the individual (GERE, 1957).

Table 3 also provides information about the significant nitrogen content of the excrement. Since caterpillars do not digest their food very much, the nitrogen present in their excrement is largely in the form of macromolecules that are not directly accessible to plants. Our experimental millet plants (*Panicum miliaceum*) grown in fresh caterpillar waste suffered from slight nitrogen deficiency. However, the fragments of plants getting into the excrement are broken into tiny pieces as a result of the chewing process, thus ending up with a very large surface area. And because of its huge surface area, this matter becomes very much accessible to bacteria and fungi, facilitating very intense processes of decomposition. The excrement is thus recycled much quicker than pieces of dead plants.

This process means that the excrement speeds up eutrofication. This effect is opposite to that of the metabolism of the lepidoptera. Therefore, if we wish to evaluate the effects of Lepidoptera, or in general other living organisms, on water, we have to reckon with such complex and contradictory effects.

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