DIVERSITY OF GALL-INDUCING LEPIDOPTERA: TOWARD THE WORLD SYNOPTIC LIST

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Abstract: Updated records since the appearance of Miller (2005) reveal that more than 550 morphospecies of gall-inducing Lepidoptera have been recorded around the world, and these belong to at least 23 families in 12 superfamilies (figure 1, table).
The families Heliodinidae, Choreutidae, and Pyralidae are new to the gall-inducing list. Some major gall-inducing families are Coleophoridae, Cosmopterigidae, Gelechiidae, (Gelechioidea), Sesiidae (Sesioidea) and Tortricidae (Tortricoidea).
The genus *Mompha* (Coleophoridae: Momphinae) contains more than 72 species of gallers, being most diverse within a single genus. The genus *Gnorimoschema* (Gelechiidae) comes in second place with 18 species. To date, galling is unknown in butterflies and other lineages of Macrolepidoptera (figure 1); however, nearly 50 % of gall-inducing lepidopterans have been identified only as far as order. Assembling a world catalog will accelerate further investigation of gall-inducing Lepidoptera.
Gall definition for Lepidoptera is provided and explained.

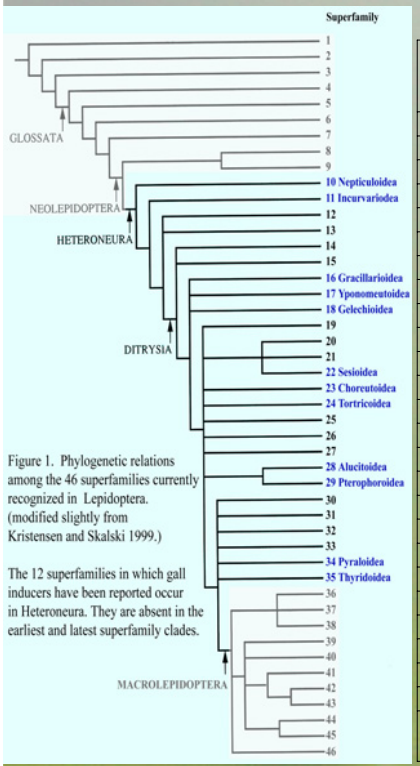

Figure 1. Phylogenetic relations among the 46 superfamilies currently recognized in Lepidoptera. (modified slightly from Kristensen and Skalski 1999.)

The 12 superfamilies in which gall inducers have been reported occur in Heteroneura. They are absent in the earliest and latest superfamily clades.

Definition of gall-inducing Lepidoptera/plant galls induced by Lepidoptera

Any stage of Lepidoptera (from egg to adult) that has an intimate relation with any part of its host plant and causes abnormal tissue or organ growth, subgrowth, regrowth, or modification via chemical or mechanical stimuli, such growth or modification being partially or totally utilized by the inducer to complete its life cycle.

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Table. Species number among gall-inducing families. August 2005

* new to the gall-inducing list

Super-fam. # in Fig. 1	Family	Miller 2005	Nishida & Miller 2005 new records	Subtotal /Total
10	Nepticulidae	6	4	10
11	Heliozelidae	4	0	4
11	Prodoxidae	2	2	4
11	Cecidocidae	7	1	8
16	Bucculatricidae	5	0	5
16	Gracillariidae	4	8	12
17	Yponomeutidae	4	0	4
17	Ypsolophidae	1	0	1
17	Glyphipterigidae	1	0	1
17	Heliodinidae *	-	1	1
18	Elachistidae (Agonoxeninae)	4	4	8
18	Oecophoridae	2	1	3
18	Coleophoridae (Coleophorinae)	7	4	11
18	Coleophoridae (Momphinae)	6	66	72
18	Cosmopterigidae	13	12	25
18	Gelechiidae	49	1	50
22	Sesiidae	19	17	36
23	Choreutidae *	-	1	1
24	Tortricidae	39	10	49
28	Alucitidae	2	8	10
29	Pterophoridae	2	1	3
34	Crambidae	1	5	6
34	Pyralidae *	-	1	1
35	Thyrididae	3	0	3
	unknown or unidentified	173	52	225
	Subtotal/Total	354	198	552

Remarks on the definition and galls induced by Lepidoptera

The definition includes facultative gallers.

The definition for obligatory gallers adds just two more words in the last sentence: the growth either partially or totally is utilized **in order** to complete its life cycle.

The definition can be applied under any conditions, e.g. natural, manipulated, and laboratory conditions.

Usually the galls are induced by the larvae, and the larvae are enclosed by the gall growth, i.e. a larva is bounded by a limited space.

Many of the galls are tissue or organ modifications via excessive growth which are seen externally; however, there are galls that are modified only internally and cannot be recognized unless they are dissected and closely examined, e.g. *Paratergeticula pollenifera* (Prodoxidae) on *Yucca schottii* seed capsules (Powell 1984).

The galls are utilized as: larval food source, shelters for eggs, larvae, and pupae (including pupation purpose), or any combination of these.

Leaf-folding galls can be distinguished from leaf folds, leaf rolls, and tied leaves by observing any secondary plant tissue growth. The growth is usually seen as thickening and hardening of the leaf tissue, and can accompany formation of a tightly sealed and swollen chamber after folding of the leaf. This means that the force of strands of silk spun by the larva(e) can be used in the process of gall formation, but it has to accompany some kind of secondary growth in the leaf tissue, i.e. just folding or tying of plant parts causing deformation in growth are not considered galls. Curling or deformations of the leaves, leaf buds, and stem shoots with or without silk support, via internal or external feeding damage, without any secondary growths are also not considered as galls, e.g. leaf miners causing distortion on leaves.

As more galls are being discovered and subjected to studies, it is probable that there will be situations in which it is questionable as to whether or not a specimen should be considered a gall according to the definition above. Re-examining the definition will be necessary as studies advance.

Any survey of galling in Lepidoptera will suffer from a degree of incompleteness. Lepidoptera families are still being discovered—three new families have been described since 1978—as tropical areas are explored; larval habits are still unknown for 13 families (Heppner 1998). Of the 97 galls Houard (1922–23) listed for Asia-Oceania as lepidopteran, 90 percent were identified no further than order Lepidoptera, and there is little evidence of subsequent descriptive progress. Likewise, more than half of the 27 lepidopteran gallers recently reported from India have yet to be identified beyond order Lepidoptera (Mani 2000).

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References

Heppner, J. B. 1998. Classification of Lepidoptera. Part 1. Introduction. Holoarctic Lepidoptera, 5, supplement 1: 1-154.

Houard, C. 1922-1923. *Les zoocécidies des plantas d'Afrique, d'Asie et d'Océanie.* Tome second. Librairie Scientifique Jules Hermann, Paris. 499-1085 pp.

Kristensen, N. P. and A. W. Skalski. 1999. Phylogeny and palaeontology. pp. 7-25. *in* Kristensen, N. P. (ed.). *Handbook of Zoology: Lepidoptera, moths and butterflies Vol. 1: Evolution, systematics, and biogeography.* Walter de Gryter, Berlin. x + 491 pp.

Mani, M.S. 2000. Plant Galls of India (2nd ed.) Science Publishers, Inc., Enfield, New Hampshire. 477 pp.

Miller, W. E. 2005. Gall-inducing Lepidoptera, pp. 431-465. In Raman, A., C. W. Schaefer and T. M. Withers (eds.). Biology, ecology, and evolution of gall-inducing arthropods. 2 vols. Science Publishers, Enfield, N. H., USA

Powell, J. A. 1984. Biological interrelationships of moths and *Yucca schottii.* Entomology vol. 100. Univ. of California Publ. vii + 93 pp.

Background photos: a new species of leaf-mining and gall-inducing "*Acrocercops*" sp. (Gracillariidae) on *Clusia*. (leaf-mines, leaf-galls, cocoons, and adult). Photos by K. Nishida.
Gall drawings are taken from Miller 2005.
Poster was designed by K. Nishida.