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WING VENATION PATTERN OF SHORT HORNED GROSSHOPPERS BASED ON THEIR MORPHOMETRY

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ABSTRACT

The present investigation was undertaken to study the body weight, body length, forewing and hindwing pattern of chosen 21 species of short horned grosshoppers (Acridids). These species were documented and their wing pattern at species levels were studied based on their morphometry. The morphological features of the wings are useful in understanding their flight behaviour, phylogeny and taxonomy. The overall wing venation pattern analysis of the Acridids species studied found species specific wing pattern and no species had any specific single wings based morphotraits. The wing pattern variables namely costa, cubitus, media and radius could together be useful in species identification. Wing morphology of short horned grosshopper and venation pattern have been reported in most of the insect groups and used for analysing their divergence and convergence.

I. INTRODUCTION

Morphotraits are still useful in classification of living nature since 18th century. This organism approaches select and compare different organ system to characterize various taxonomic hierarchies of systematic. Entomofauna are one of the most successful groups of organism on Earth due to the presence of wings, high biotic potential, shorter generation times and etc., Earlier, all the animals were grouped based on their homology pattern of various morphological traits and they are still useful in their classification. Insect wings are used as subject matter for taxonomy to phylogeny from earlier times. Only the wings of the meso and meta thorax seem over to have become fully developed as flight organs. Most of previous studies on insect flight consider the aerodynamic functions of the wings. However to studies of the functional significance of any system its morphology must first be investigated. It is known the insect wing movements are controlled by selerites at the wing base, but according to (Wootton, 1981) the venation pattern also play an important role in the control of these movements.

Insect wings possess a number of characters that can help to identify a specimen. One useful character is provided by the presence of structural elements that give rigidity to the airfoil itself; these structural elements are modified tracheae known as “veins”. The total number of veins is an aid in identification. Another useful character is the general overall pattern in which the veins interconnect. The number of veins and their basic sequence of branching are characteristic enough to be able to discriminate insects to the family or subfamily level. The precise measurement of the vein intersections is often useful for species-level identification. However, sometimes unrelated families share the same sequence pattern; conversely, sometimes individual genera within a family may be characterized by different basic sequences. Currently the effort it takes to identify an insect to the family level depends upon the expertise of the person. Only very broadly trained entomologists can sight-identify most winged insects to family level. The usual practice is to utilize published “dichotomous keys”, which can be a rather lengthy process. Identification to a finer level of resolution (genus- or species-level) is extremely tedious and takes a very extensive library of specialized reference publications. The Bug Wing system has been devised to allow the untrained ecologist to identify insects very quickly. It can always be supplemented with conventional techniques.

While insect wings may appear dry and lifeless in a dead insect, in living insects the wings contain circulating haemolymph (in the wing veins), sensory neurons associated with wing sensillae, and tracheae, which provide oxygen to the living cells of the wing. The systems of nomenclature that have developed around identifying wings can appear confusing, and the criteria used for identifying homologous wing veins across the insect orders obscure at best. Wings have many other variable elements: planform, relief, richness of venation and complexity of folding. From an engineering viewpoint, insect wings are at once levers, oscillating airfoils, and cantilevered beams (Wootton, 1992).

In modern entomology, there are three main approaches to the homology and nomenclature of the wing veins in insects. One, developed by (Kukalova Peck, 1978, 1991), proceeds from the metameric organization of the wing, with six homonomous vein systems, namely costal (C), subcostal (SC), radial (R), medial (M), cubital (Cu), and anal (A). Each system originally dichotomizes into a convex (raised above the membrane, labelled with +) anterior vein and a concave (slightly depressed and labelled with -) posterior one. The anterior of these veins is traditionally marked by the addition of the letter A (anterior), the posterior one by P (posterior): CA, CP, RA, RP, MA, MP, CuA, CuP, AA, AP. Each vein may be further subdivided, normally retaining its sign (+ or -).

The second approach is historically a derivative of the first, but it accentuates obligatory preservation of the vein position rather than metamery (six homonomous principal veins); thus, if the visible CuA base is concave, then it is not CuA but CuP. The third approach is an old but constantly developing, changing and in general not too strict pattern including the veins C, SC, R with its posterior branch RS (homologues of RA and RP in Kukalova-Peck's pattern) M, which is accepted as consisting of MA and MP when necessary, Cu with constant branches CuA and Cup, and one or several anal veins (Rasnitsyn, 2007).

In the present investigation the forewing and hindwing pattern of chosen Acridid species were documented and their pattern at species levels were studied based on their morphometry.

2.MATERIALS AND METHODS

Twenty one species of orthoptera belong to the two families such as Acrididae and Pyrgomorphidae were collected using Sweep-net technique from different agroecosystems in Madurai District (Table 1). Wings were separated from the sacrificed acridids and preserved using 70% alcohol. Those preserved wings were spread and morphometric measurements were recorded using handles. The number and arrangements of the wing veins is of great value in identification, particularly in those groups of insects that have membranous wings. There is a great deal of variation in the wing venation of different insects, but it is possible to homologize the veins and to use a system of terminology applicable to almost all insects. This system is called the Comstock- Needham system and is applied in the present study.

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2.1. Longitudinal veins:

The longitudinal veins and most of the cross-veins bear names. These (with their abbreviations in parentheses) are given below together with their corresponding location in the wing. The longitudinal veins vary somewhat in their method of branching in different insects, but the basic or hypothetical primitive arrangement is as follows:

Costa (C) – an unbranched vein that usually forms the anterior (costal) margin of the wing.

Subcosta (Sc) – is forked distally. (The branches of the longitudinal veins are numbered from anterior to posterior around the wing by means of subscript numerals). The two branches of the subcosta are designated Sc_1 and Sc_2.

Radius (R) – gives off a posterior branch, the Radial Sector (Rs), usually near the base of the wing; the anterior branch of the radius is R_1. The Radial Sector (Rs), the posterior branch of the radius, forks twice, with four branches reaching the wing margin, respectively R_2, R_4 and R_5.

Medius (M) – forks twice, four branches reaching wing margin, M_1, M_2, M_3 and M_4.

Cubitus (Cu) – according to the Comstock-Needham System it forks once, the two branches being Cu_1 and Cu_2; according to some other authorities, Cu_1 forks again distally, the two branches being Cu_{1a} and Cu_{1b}.

Anal Veins (A) – are typically unbranched and are designed from anterior to posterior as first anal (1A), second anal (2A) and third anal (3A).

MA – media anterior
MP – media posterior

Table 1. Acridids Species studied for their wings pattern

Sl.No	Species Name	Sub family	Family
1	*Phlaeoba infumata*	Acridinae	Acrididae
2	*Acorypha insignis*	Calliptaminae	Acrididae
3	*Xenocatantops humilis humilis*	Catantopinae	Acrididae
4	*Anacridium flavescens*	Cyrta canthacridinae	Acrididae
5	*Eucoptacra praemorsa*	Coptacridinae	Acrididae
6	*Epistaurus sinetyi*	Coptacridinae	Acrididae
7	*Eyprepocnemis alacris alacris*	Eyprepocnemidinae	Acrididae
8	*Heteracris pulcher*	Eyprepocnemidinae	Acrididae
9	*Tylotropidius variecorinis*	Eyprepocnemidinae	Acrididae
10	*Aulacobothrus socius*	Gomphocerinae	Acrididae
11	*Leva cruciata*	Gomphocerinae	Acrididae
12	*Acrotylus humbertianus*	Oedipodinae	Acrididae
13	*Gastrimargus africanus sulphureus*	Gomphocerinae	Acrididae
14	*Heteropternis respondens*	Gomphocerinae	Acrididae
15	*Pternoscirta bimaculata*	Gomphocerinae	Acrididae
16	*Trilophidia annulata*	Gomphocerinae	Acrididae
17	*Oedaleus senegalensis*	Gomphocerinae	Acrididae
18	*Gesonula punctifrons*	Oxyinae	Acrididae
19	*Oxya nitidula*	Oxyinae	Acrididae
20	*Poekilocerus pictus*	Pyrgomorphinae	Pyrogomorphidae
21	*Pyrgomorpha bispinosa*	Pyrgomorphinae	Pyrogomorphidae

3. RESULTS

Among key insect groups, Acridids (grasshoppers and locusts) cause severe loss by devastating crop plants, plantation, pastures and rangelands. Thereby they become responsible for food and fodder shortages in many parts of the world by damaging substantial amounts of all crops and their control require great expenditures. The family Acrididae is large and diverse, comprising 35 sub-families and distributed throughout the world. The most important groups of Orthoptera causing economic injury are in the family Acrididae called plague locusts (gregarious and migratory grasshoppers) that pose major problems in the old world tropics. Grasshoppers include locusts and they are known for their flight adaptation. Forewing venation patterns are found to be highly complex, hence phylogenetically informative and improved knowledge of the early evolution of a taxon that represents more than half of the extant biodiversity, namely the winged insect. In the present investigation the body weight, body length and wing pattern of twenty one Acridids were documented and presented in Table 2 & 3.

Anacridium flavescens recorded maximum body weight (1600 mg) and lowest body weight was recorded in Oxya nitidula (180 mg). Total body length was maximum in the species A. flavescenes (80 mm) and Leva cruciata was the shortest species (15 mm) among the species studied.

3.1. Forewing pattern:

The lengthiest forewing was found in Gastrimargus africanus sulphurous (54 mm) which equals to the body length and the shortest forewing i.e. 14 mm was found in the two acridid species namely, Phlaeoba infumata and L. cruciata. Width of the forewing ranged between 2mm and 14mm and Poekilocerus pictus of the family Acrididae recorded the maximum width of 14 mm.

The wing venation namely Costa, Cubitus, Media and Radius of the forewing were measured and presented in the Table 2. The Costa was lengthiest in A. flavescens (31 mm) and shortest in P. infumata (1 mm). The Cubitus ranged from 11 to 40 mm and 14mm of cubitus length was observed in the five species viz., Epistaurus sinetyi, Eyprepocnemis alacris alacris, L. cruciata, Heteropternis respondens and Pyrgomorpha bispinosa. The media had maximum length in G. a. sulphurous (49 mm) and shortest in P. infumata (12 mm).

The ratio of body length and body weight was higher in Oxya nitidula (0.150) and P. bispinosa (0.103) and lowest ratio of 0.037 was recorded in E. a. alacris. Eucoptacra praemorsa, Epistaurus sinetyi, Acrotylus humbertianus, G. a. sulphurous, Oedaleus senegalensis and Poekilocerus pictus had ratio of forewing length and body higher than 1.0 as their forewing were longer than the body length.

Table 2. Morphometrics of Fore wing of the acridids studied

Sl.No	Species Name	Body weight (mg)	Total Body length(mm)	Fore wing		Costa (mm)	Cubitus (mm)	Media (mm)	Radius (mm)	Ratio of body length&body Weight	Ratio of Fore wing & Body length
				Length	Width						
1	*Phlaeoba infumata*	310	30	14	2	10	11	12	13	0.097	0.467
2	*Acorypha insignis*	320	21	19	4	15	16	17	19	0.066	0.905
3	*Xenocatantops humilis humilis*	390	29	16	3	9	13	14	15	0.074	0.552
4	*Anacridium flavescens*	1600	80	51	9	31	40	48	50	0.050	0.638
5	*Eucoptacra praemorsa*	320	20	34	7	22	23	28	29	0.063	1.700
6	*Epistaurus sinetyi*	390	18	18	4	11	14	17	18	0.046	1.000
7	*Eyprepocnemis alacris alacris*	1110	41	19	4	11	14	18	19	0.037	0.463
8	*Heteracris pulcher*	400	28	20	4	14	15	17	18	0.070	0.714
9	*Tylotropidius variecorinis*	430	31	24	5	14	20	22	24	0.072	0.774
10	*Aulacobothrus socius*	310	29	21	4	11	13	18	19	0.094	0.724
11	*Leva cruciata*	180	15	14	3	15	14	16	17	0.083	0.933
12	*Acrotylus humbertianus*	390	25	25	5	13	18	19	20	0.064	1.000
13	*Gastrimargus africanus sulphureus*	1150	54	54	11	30	36	49	51	0.047	1.000
14	*Heteropternis respondens*	270	21	20	5	10	14	17	19	0.078	0.952
15	*Pternoscirta bimaculata*	320	25	23	4	15	17	20	22	0.078	0.920
16	*Trilophidia annulata*	600	27	20	3	10	15	17	19	0.045	0.741
17	*Oedaleus senegalensis*	380	32	40	8	20	29	33	38	0.084	1.250
18	*Gesonula punctifrons*	550	25	18	3	6	12	15	17	0.045	0.720
19	*Oxya nitidula*	180	27	20	3	14	15	17	19	0.150	0.741
20	*Poekilocerus pictus*	520	29	38	14	16	28	32	37	0.056	1.310

3.2. Hindwing pattern:

Width of the hind wing in all the species of the two families such as Acrididae and Pyrgomorphidae studied was far higher when compared to width of forewings. Length of hind wing was exceeded the body length in the species E. pramorsa, O. senegalensis and P. pictus. A. flavescens had maximum length of all wing pattern variables namely Costa (25 mm), Cubitus (34 mm), Media (41 mm) and Radius (47 mm) and those wing venation variables were least in X. h. humilis (Table 3). The ratio of hindwing length and body length ranged between 0.400 (P. infumata) and 1.650 (E. praemorsa).

Table 3. Morphometrics of Hindwing of the acridids studied

Sl.No	Species Name	Body weight (mg)	Total Body length(mm)	Hind wing		Costa (mm)	Cubitus (mm)	Media (mm)	Radius (mm)	Ratio of body length&body Weight	Ratio of Hind wing & Body length
				Length	Width						
1	*Phlaeoba infumata*	310	30	12	13	6	11	13	13	0.097	0.400
2	*Acorypha insignis*	320	21	17	18	10	12	15	15	0.066	0.810
3	*Xenocatantops humilis humilis*	390	29	19	20	4	10	12	13	0.074	0.655
4	*Anacridium flavescens*	1600	80	49	51	25	34	41	47	0.050	0.613
5	*Eucoptacra praemorsa*	320	20	33	32	12	23	26	28	0.063	1.650
6	*Epistaurus sinetyi*	390	18	16	17	7	10	14	14	0.046	0.889
7	*Eyprepocnemis alacris alacris*	1110	41	17	18	8	13	14	16	0.037	0.415
8	*Heteracris pulcher*	400	28	17	18	5	13	15	16	0.070	0.607
9	*Tylotropidius variecorinis*	430	31	21	23	10	16	18	20	0.072	0.677
10	*Aulacobothrus socius*	310	29	19	21	9	14	16	17	0.094	0.655
11	*Leva cruciata*	180	15	15	16	12	13	14	14	0.083	1.000
12	*Acrotylus humbertianus*	390	25	21	22	10	16	18	20	0.064	0.840
13	*Gastrimargus africanus sulphureus*	1150	54	48	49	24	33	40	46	0.047	0.889
14	*Heteropternis respondens*	270	21	19	20	5	15	16	18	0.078	0.905
15	*Pternoscirta bimaculata*	320	25	21	22	10	16	19	20	0.078	0.840
16	*Trilophidia annulata*	600	27	19	20	7	14	15	17	0.045	0.704
17	*Oedaleus senegalensis*	380	32	36	39	13	28	32	34	0.084	1.125
18	*Gesonula punctifrons*	550	25	15	17	6	11	14	15	0.045	0.600
19	*Oxya nitidula*	180	27	20	21	8	12	16	18	0.150	0.741
20	*Poekilocerus pictus*	520	29	34	35	12	28	29	33	0.056	1.172
21	*Pyrgomorpha bispinosa*	330	34	21	21	17	16	18	20	0.103	0.618

4.DISCUSSION

Wings of insects are believed to be a monophyletic adaptation that allowed insects to exploit new niches, resulting in rapid diversification. Wings have evolved a range of sizes, shapes, colours, and patterns of venation to meet a variety of functional requirements. The wing is a classical example of convergent evolution in action. Additionally, wing colour patterns are important in sexual selection, mimicry and predator avoidance, and these functions have been the topic of several recent studies. In the present study, twenty two species orthopteran insects were selected and body weight, body length and wing pattern have been described for each species. The wing venation namely Costa, Cubitus, Media and Radius were measured and presented (Table 2&3). Insect wings are immensely varied and there were sporadic and limited information on wing pattern of insects in India. Wings are examples of light-weight structures combining a minimum of materials with highest performance. This was one reason for the stunning success of Pterygotes. The wings of insects while evaginations of the body wall do not function like a vertebrate wing. The morphological features of the wings are useful in understanding their flight behaviour, phylogeny and taxonomy. Wings surface area is designated into various specific sub area-spaces called cells, based surrounded by typical vein system. After the revision of several fossils and observations of recent taxa, (Bethoux and Nel, 2002) proposed a new interpretation of the wing venation pattern for the orthopteroid lineage. The orthoptera and several taxa previously assigned to the paraphyletic group “Protoorthoptera” are included in a common clade, Archaeorthoptera taxa nov. The venation patterns characteristics of different insect orders and of families belonging to the same order posses enormous variation in vein number, position and differentiation (Celis and diaz-Benjuumea, 2003). The wing shape and vein pattern is species-specific and is used taxonomically (Comstock, 1940) and also in studies of fluctuating asymmetry (Klingenberg et al., 2001).

5.conclusion

Twenty one species of Orthoptera, belonging to two families such as Acrididae, and Pyrgomorphidae were collected using Sweep-net technique from different agroecosystems in Madurai districts for studying their wing venation pattern. Comstock-Needham system was carried out to record the wing venation pattern of the selected Acridid species. A.flavescens recorded maximum body weight and lowest body weight was by Oxya nitidula. Total body length was maximum in the species A. flavescenes and Leva cruciata was the shortest species among the species studied. The lengthiest forewing was found in Gastrimargus a. sulphurous and the width of the forewing was larger in Poekilocerus pictus. Width of the hind wing in all the species of the two families such as Acrididae and Pyrgomorphidae studied was far higher when compared to width of forewings.The wing venation namely Costa, Cubitus, Media and Radius of the forewing and hindwing of the Acridids were documented. The wing pattern variables of forewing were highly varied among the acridid species and all wing pattern variables of hindwing namely Costa, Cubitus, Media and Radius were maximum in length in A. flavescens.

The overall wing venation pattern analysis of the Acridid species studied found species specific wing pattern and no species had any specific single wings based morphotraits. The wing pattern variables namely costa, cubitus, media and radius could together be useful in species identification.

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