Beitr. Ent., Berlin 30 (1980) 1, S. 9–14

Government Agriculture College
Sopore (Wadoora), Kashmir (India)

M. Zaka-Ur-Rab

Morphology of the male terminalia of *Aedes aegypti* Linnaeus, the Yellow Fever Mosquito

(Diptera: Culicidae)

With 6 text figures

Abstract

A detailed study has been made of the male terminalia of *Aedes aegypti* Linnaeus, the yellow fever mosquito, with special reference to its skeleto-muscular system. A number of hitherto unrecorded muscles have been described, and many anatomical features have been interpreted on sound morphological basis to bring out their real identity.

Introduction

The male terminalia of mosquitoes seem to have attracted the attention of quite a number of entomologists but perhaps the taxonomical expediency denuded the terminalia of their morphological meaning, and plunged them into an abyss of taxonomical jargon. It is not surprising, therefore, that inspite of a considerable amount of literature published on the male terminalia of mosquitoes, one fails to come across a really good work on the skeleto-muscular system based on sound morphological foundations.

Among notable works on the male terminalia, mention may be made of Christophers (1915, 1922), Rees & Onishi (1951), Snodgrass (1959), Edwards (1920), Freeborn (1924), Martini (1922), and Nuttal & Shipley (1903). Christophers (1960) is the most comprehensive account yet published on a mosquito, but even here the work suffers for the same defects referred to above. Studies in chaetotaxy and taxonomical anatomy seem even here to have taken the upper hand.

The Terminalia

As is the case in all mosquitoes, the terminalia of *Aedes aegypti* have undergone rotary inversion through 180°, which has reversed the normal position of the terga and sterna composing the terminalia.

The eighth segment is a prominent feature of the terminalia, and completely conceals the ninth segment. Its tergum is well developed and as a result of rotation, occupies a ventral position. The eighth sternum, likewise, occupies a dorsal place. Basally, the eighth segment is partially telescoped into the preceding segment.

The ninth segment (Figs. 1, 2) is greatly reduced and is completely concealed by the eighth segment. Its tergum (T_9) and sternum (S_9) are in the form of posteriorly concave, narrow sclerotic plates. Basally, the ninth sternum projects in the lumen of the eighth segment in the form of a slightly crescentiform phragma (*Ph*).

Ventro-laterally, the ninth sternum is produced in the form of narrow sclerotic bars (Figs. 1, 2; *scb*) which fuse with the antero-lateral angles of the ninth tergum on each side. This situation is exactly the reverse of what has been described by Christophers (1960) in *Aedes aegypti*, where according to him, it is the 'ninth tergite' which is produced in the form of 'stout rib-like bars', which descend to meet the sternite. Rees and Onishi (1951) in *Culiseta inornata* call these bars of the ninth sternum as 'pleura'.

The present writer could not also make out the 'flat triangular expansions' described by Christophers (1960). It appears that the internal apodemal inflection of the basimere (Figs. 1, 2, 5; *ifn*) which, in lateral mounts, occupies a position similar to that described for

DOI: 10.21248/contrib.entomol.30.1.9-14

'triangular expansions' by CHRISTOPHERS, has erroneously been regarded as a definite triangular sclerite by him, owing to the transparency of the over-lying membrane. Such optical mistakes are not rare in anatomical descriptions based on specimens mounted on slides.

The parameres are composed of two pairs, an outer and an inner. The outer parameres (Figs. 1, 2; *PMR*) are very well developed, and are the most conspicuous feature of the male terminalia. Each outer paramere consists of a large basimere (*bmr*), and a narrow telomere (*tmr*) which is rather claw-like in appearance, and apically bears a stout peg. Antero-ventrally, the basimere internally projects in the form of an apodemous inflection (*ifn*) which serves both as a seat for attachment of muscles, as well as a brace for the aedeagus (*Aed*), through the intervening basal sclerites (Figs. 3,5; *bp*).

The basimeres also provide muscles to the telomeres which are movably articulated to the former. CHRISTOPHERS (1960) calls the outer parameres as 'gonocoxites' and the telomeres as 'styles'. REES & ONISHI (1951) term the telomere as 'clasper' and the basimere as 'side piece'. CRAMPTON (1942), and SNODGRASS (1957, 1959), however, rightly call these structures as parameres.

The basal inflection of the outer paramere (*ifn*) of *A. aegypti* described presently, is comparable to the 'external apodeme' and the 'basal apodeme' together, described in the same insect by CHRISTOPHERS (1960).

The inner parameres (Figs. 1, 2, 5; *pmr*), in contrast to the outer ones, are relatively much reduced. Each paramere consists of a basal portion (*b*) and an apical portion (*a*) which is movably articulated to the former. The real nature of these inner parameres has hitherto been ignored, and they have been variedly interpreted by entomologists. CHRISTOPHERS (1960) considers the apical portion to represent the 'paraproct' and the 'cercus', and the basal portion as 'probably the eleventh sternite'. He shows the latter to be basally connected with the ninth 'tergite'. This, obviously, is an indefensible contention. REES & ONISHI (1951) call the basal portion as 'paramere', and the distal portion as 'interbasal plate'. CRAMPTON (1942) does not commit himself as to the true morphological nature of these structures. MICHENER (1944) calls these as 'volsellae' in *Aedes dorsalis*. SNODGRASS (1957, 1959), in line with many culicidologists, calls these structures as 'claspettes'. However, it may be pointed out here, inspite of his own observation (ref. 1957; p. 48) that 'they are always connected with the inner face of the parameres', and that of CHRISTOPHERS (1922) that the rudiments of the claspettes are cut off from the base of the parameres in the course of postembryonic development, SNODGRASS does not recognise their true morphological nature and considers them to be 'secondary' structures. Such a stand gathers little justification, particularly in the light of developmental studies by ABUL-NASR (1950) on the genitalia of certain Nematocera. His observations clearly show that the inner parameres are a regular feature of the Nematocera and that their rudiments arise from the basal portion of the lobes of the outer parameres. In some cases these rudiments further subdivide to produce a pair of median lobes and a pair of outer lobes. The former unite with each other to form the aedeagus or the 'penis valves', and the outer lobes remain as inner parameres.

The apical portion (*a*) of the inner paramere receives muscles from the internal basal inflection of the outer paramere. The basal portion (*b*) of the inner paramere is connected with the basal portion of the inner wall of the outer paramere (Fig. 5). This connection has also been recorded by CHRISTOPHERS (1960) but, as already mentioned earlier, he considers the basal portion to represent the eleventh sternite.

The intromittent organ of *A. aegypti* is an aedeagus (Figs. 3, 5; *Aed*), called 'phallosome' by CHRISTOPHERS (1960), and 'mesosome' by REES & ONISHI (1951). It is a short tubular structure consisting of two curved, highly pigmented sclerites, giving it in the words of CHRISTOPHERS, the appearance of a 'slightly open cockle shell'. These sclerites which are contiguous posteriorly, diverge from each other towards the anterior aspect. Here these sclerites are indirectly articulated with the basal internal inflection of the outer paramere on each side, through the basal sclerites (Fig. 5; *bp*). CHRISTOPHERS (1960) calls the basal sclerites as 'parameres'. These sclerites, however, cannot be considered to represent the

DOI: 10.21248/contrib.entomol.30.1.9-14

parameres by any stretch of imagination. REES & ONISHI (1951) term these structures as 'arms' of the 'mesosome'.

The proctiger (Fig. 5; *Ptgr*), composed of the tenth and eleventh segments, is an entirely membranous structure and bears the anus at its end.

Muscles of the Terminalia

Besides the muscles which are responsible for the movement of the aedeagus and the two sets of parameres, other muscles of the terminalia can conveniently be placed in three categories, viz., the inter-tergal muscles, the inter-sternal muscles, and the tergo-sternal muscles. The last mentioned muscles are in the form of a thin sheet extending between the eighth tergum and the sternum on either side, and have been excluded from the description which follows.

I. Inter-tergal muscles:

Retractor of the ninth tergum: (Fig. 4; No. 1)

This short muscle arises from the posterior margin of the eighth tergum, on the medio-lateral aspect, and is inserted medially on the basal rim of the ninth tergum. It has not been described by CHRISTOPHERS (1960).

II. Inter-sternal muscles:

Retractor of the ninth sternum: (Fig. 3; No. 2)

This short muscle arises medio-laterally on the posterior margin of the eighth sternum, and is medially inserted on the basal margin of the ninth sternum. CHRISTOPHERS (1960) does not record this muscle.

Depressor of the ninth segment: (Figs. 5, 6; No. 3)

This long muscle arises postero-laterally on the eighth sternum, and passing outer to the levator of the ninth segment, gets inserted on the sclerotic bar just before the latter fuses with the lateral angle of the ninth tergum. The contraction of this muscle depresses the entire ninth segment alongwith the parameres at the time of copulation, closely abutting these structures against the female terminalia, a fact also observed by REES & ONISHI (1951) in *C. inornata*. This muscle has also not been recorded earlier.

Levator of the ninth segment: (Figs. 5, 6; No. 4)

This muscle arises antero-laterally on the eighth sternum, and is inserted laterally on the sclerotic bar of the ninth sternum, passing mesal to the depressor of the ninth segment. This muscle works antagonistically with reference to the latter. This muscle is also being recorded for the first time.

III. Muscles of the parameres:

Adductor of the outer paramere: (Fig. 3; No. 5)

This broad muscle arises laterally on the internal phragma of the ninth sternum, and is inserted mesally on the base of the basimere of the outer paramere. CHRISTOPHERS (1960) terms this muscle as 'retractor of the basal lobe'.

Abductor of the outer paramere: (Fig. 4; No. 6)

This conical muscle arises antero-laterally on the ninth tergum, and is inserted laterally on the base of the basimere of the outer paramere. This muscle is being recorded also for the first time.

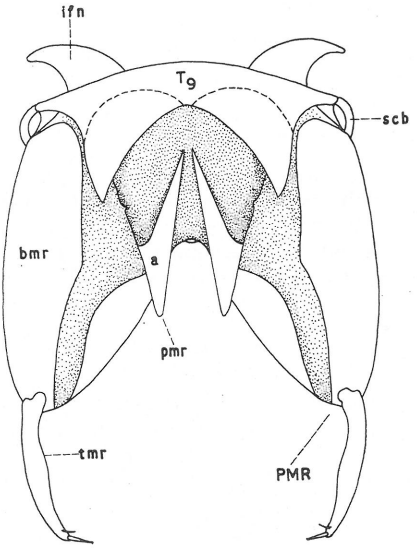
Adductor of the inner paramere: (Fig. 4; No. 7)

This muscle arises on the internal inflection (*ifn*) of the basimere of the outer paramere, and is broadly inserted on the apical portion of the inner paramere of its side. It appears to be homologous with the 'muscle bands arising from tenth tergite and inserted into the basal apodeme posteriorly' described by CHRISTOPHERS (1960).

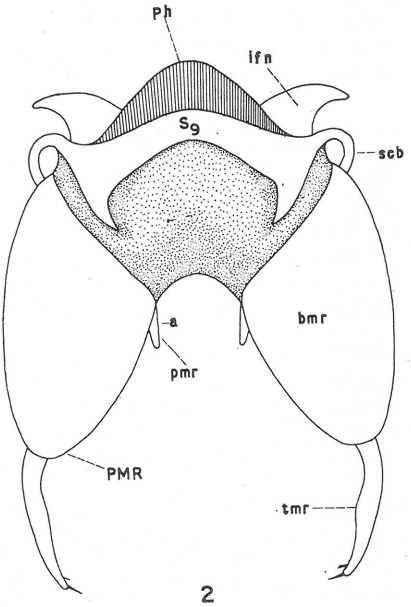
Flexor of the telomere: (Fig. 4; No. 8)

This long muscle arises on the internal inflection (*ifn*) of the basimere of the outer paramere, and is inserted on the inner tubercle of the base of the telomere. It is homologous with the 'adductor of the style' described by CHRISTOPHERS (1960).

DOI: 10.21248/contrib.entomol.30.1.9-14

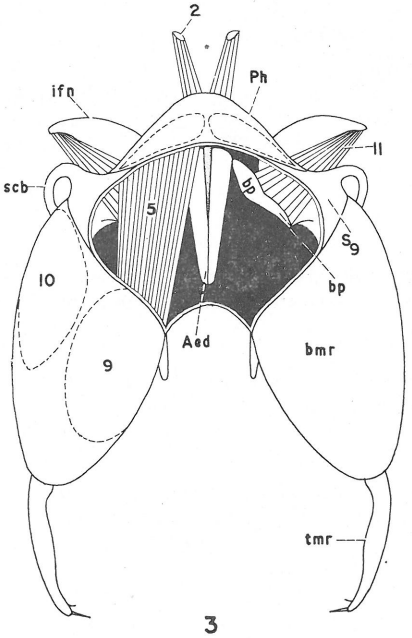


1

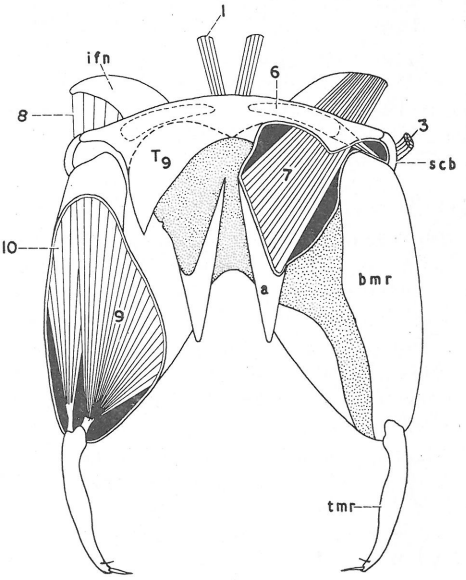


2

Fig. 1. Male terminalia in ventral view
Fig. 2. Male terminalia in dorsal view



3



4

Fig. 3. Same as 2, showing muscles. Integument partly removed
Fig. 4. Same as 1, showing muscles. Integument partly removed

DOI: 10.21248/contrib.entomol.30.1.9-14

Second flexor of the telomere: (Fig. 4; No. 9)

This massive muscle arises on the greater part of the ventral aspect of the basimere, and is inserted on the inner tubercle of the telomere. It is homologous with the 'flexor of the style' described by CHRISTOPHERS (1960).

Extensor of the telomere: (Fig. 4; No. 10)

This muscle is relatively smaller than the muscle No. 9 described above. It arises on the lateral aspect of the basimere, and is inserted on the outer tubercle of the base of the base of the telomere. It is homologous with the 'extensor of the style' described by CHRISTOPHERS (1960).

IV. Muscles of the aedeagus:

Protractor of the aedeagus: (Fig. 3; No. 11)

This small muscle arises on the internal inflection (*ifn*) of the basimere of the outer paramere, and is inserted on the basal sclerite (*bp*). It is homologous with the 'protractor of the phallosome' described by CHRISTOPHERS (1960).

Abbreviations

a	Apical portion of inner paramere	*PMR*	Outer paramere
Aed	Aedeagus	*pmr*	Inner paramere
b	Basal portion of inner paramere	*Ptgr*	Proctiger
bmr	Basimere	*Rect*	Rectum
bp	Basal sclerotic plate	*S*	Sternum
Enph	Endophallus	*scb*	Sclerotic bar of ninth sternum
ifn	Internal inflection of outer paramere	*T*	Tergum
Ph	Internal phragma of ninth sternum	*tmr*	Telomere
Phtr	Phallotreme		

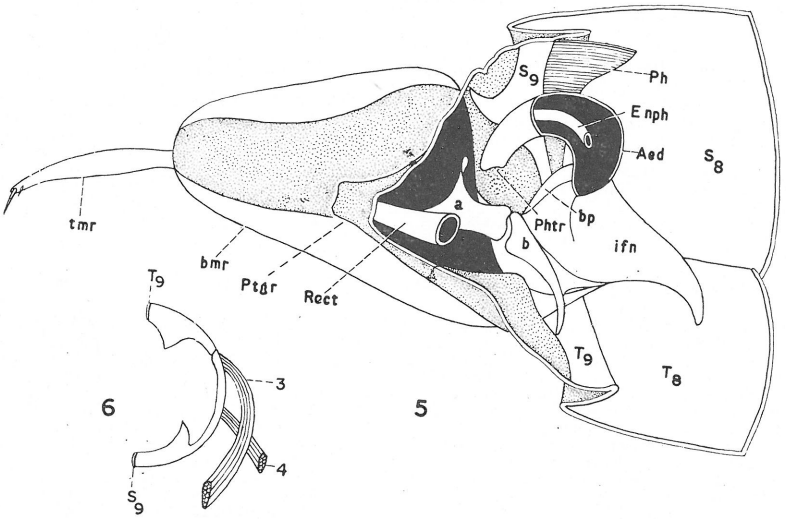


Fig. 5. Inner view of left lateral half of terminalia
Fig. 6. Muscle attachments on the sclerotic bar of ninth sternum

Summary

The morphology of the male genitals of the yellow fever mosquito *Aedes aegypti* LINNAEUS is described.

Zusammenfassung

Es wird die Morphologie der männlichen Genitalien von *Aedes aegypti* LINNAEUS beschrieben.

Резюме

Описывается морфология гениталий самцов *Aedes aegypti* LINNAEUS.

References

ABUL-NASR, S. E. The structure and development of reproductive system of some species of Nematocera. Phil. Trans. Roy. Soc. London (B), **234**, 339–96; 1950.

CHISTOPHERS, S. R. The male genitalia of *Anopheles*. Indian Journ. Med. Res. **3**, 371–94; 1915.

— The development and structure of the terminal abdominal segments and hypopygium of the mosquito. Indian Journ. Med. Res. **10**, 530–710; 1922.

— *Aedes aegypti* (L.). The yellow fever mosquito. Cambridge Univ. Press, 534 pp.; 1960.

DOI: 10.21248/contrib.entomol.30.1.9-14

CRAMPTON, G. C. The external morphology of the Diptera. Guide to the insects of Connecticut. Part II. Fascicle I. Connecticut State Geol. and nat. Hist. Surv., Bull. **64**, 10–165; 1942.
EDWARDS, F. W. The nomenclature of the parts of the male hypopygium of Diptera Nematocera with special reference to mosquito. Ann. Trop. Med. Parasitol. **14**, 25–40; 1920.
FREEBORN, S. B. The terminal abdominal structures of male mosquitoes. Amer. Journ. Hygiene **4**, 188–212; 1924.
MARTINI, E. Über den Bau der äußeren männlichen Geschlechtsorgane bei den Stechmücken. Arch. Naturg. Abt. A **88**, 134–142; 1922.
MATSUDA, R. Morphology and evolution of the insect abdomen. Pergamon Press, Oxford, 534 pp; 1976.
MICHENER, C. D. A comparative study of the appendages of the eighth and ninth abdominal segments of insects. Ann. Ent. Soc. Amer. **37**, 336–51; 1944.
NUTTAL, G. H. & SHIPLEY, A. E. The structure and biology of *Anopheles*. Journ. Hyg. **3**, 166–215; 1903.
REES, D. M. & ONISHI, K. Morphology of the terminalia and internal reproductive organs, and copulation in the mosquito, *Culiseta inornata* (WILLISTON). Proc. Ent. Soc. Washington **53**, 233–246; 1951.
SNODGRASS, R. E. A revised interpretation of the external reproductive organs of male insects. Smithson. Misc. Coll. **135**, 1–60; 1957.
– The anatomical life of the mosquito. Smithson. Misc. Coll. **139**, 1–87; 1959.

Besprechungen

Wichard, W. Die Köcherfliegen. (Trichoptera). Die Neue BREHM-Bücherei 512. A. ZIEMSEN Verlag, Wittenberg Lutherstadt. 1978; 14,5 cm × 20,5 cm; 63 S., 44 Abb. Preis 6,00 M.

Der Autor schildert nach einer kurzen Einführung über die Stellung der Trichopteren im System der Insekten und die Gliederung der Ordnung in Familien ausführlich und anregend die spezifischen Erscheinungen der merolimnischen Lebensweise dieser durch zahlreiche Anpassungen außerordentlich interessanten Tiergruppe. Besonders physiologische, ethologische und ökologische Besonderheiten des Lebens der Larven werden dargestellt und mit Hilfe guter und instruktiver Abbildungen erläutert. Kapitel über die abweichende terrestrische Lebensweise der Larven der Gattung *Enoicyla* und den Parasitismus der Schlupfwespe *Agriotypus armatus*, Erläuterungen der Fachausdrücke und ein umfangreiches Literaturverzeichnis ergänzen diese flüssig geschriebene Kurzgeschichte über die Biologie der Köcherfliegen.

PETERSEN

Lindauer, M. Verständigung im Bienenstaat. GUSTAV FISCHER Verlag, Stuttgart. 1975; 12 × 19 cm; VIII & 163 S., 83 Abb. Preis 14,80 DM.

Die von KARL VON FRISCH um 1950 bekanntgemachten Forschungsergebnisse über die Bienensprache und Orientierungsleistungen der Bienen sind heute auch der breiten Öffentlichkeit als interessantes Phänomen bekannt. In seinem Buch, eine Zusammenstellung von Vorträgen, versucht der Autor, selbst ein Schüler KARL VON FRISCHS, tiefer in spezielle Probleme einzudringen. So untersucht er beispielsweise die Unterschiede der Verständigung je nach dem Mitteilungsanliegen, wie Arbeitsteilung, Temperaturregulierung, Nistplatzsuche etc. Es wird die Phylogenie der Bienensprache diskutiert und dabei auf Abwandlungen innerhalb der Gattung *Apis* und Arten der Melipenini eingegangen. Sinnesphysiologische Probleme und die Bedeutung der Erdschwerkraft und des Magnetfeldes werden näher untersucht. Insgesamt gesehen eine kurze Zusammenfassung der neuesten Erkenntnisse auf diesem Gebiet, das durchaus auch für die Zoologie im weitesten Sinne von Interesse ist.

OEHLKE

Eastop, V. F. & Hille Ris Lambers, D. Survey of the World's Aphids. Dr. W. JUNK b. v., Publishers, The Hague. 1976; 15 cm × 22 cm; vi & 573 S. Preis 160,00 Hfl.

Die Autoren haben sich der dankenswerten Aufgabe unterzogen, einen Übersichtskatalog der Aphiden der Welt zusammenzustellen. Dabei waren sie bestrebt, die von WILSON & VICKERY (1918), BÖRNER (1952) und PATCH (1938) verfaßten Kataloge auf den neuesten Stand zu bringen und wesentlich zu erweitern, indem sie nicht nur die bisher beschriebenen Gattungen und Arten aufnahmen, sondern auch deren Klassifikation zu verbessern suchten. Um spätere Revisionen zu erleichtern, zur Stabilisierung der Nomenklatur beizutragen und zukünftig Homonymien zu vermeiden, wurden auch die Synonyme in den Katalog einbezogen und alle verfügbaren Arten nachuntersucht. Das Buch gliedert sich in zwei Teile. Im ersten sind die Gattungen und die ihnen zugeordneten Arten jeweils in alphabetischer Reihenfolge aufgeführt. Dabei werden Autor, Publikationsjahr, Zitat der Beschreibung, typische Art und Gattungssynonyme angeführt. Der zweite Teil ist ein Index der wissenschaftlichen Namen der Artgruppe (Arten, Unterarten) und der infrasubspezifischen Namen. Er dient dem Auffinden eines jeden Namens dieser Kategorien. Durch den Zusatz eines oder mehrerer Gattungsnamen im Index kann unter Verzicht auf Seitenzahlen auf alle im Teil 1 vorkommenden Kombinationen verwiesen werden, da die Gattungen dort alphabetisch geordnet sind. Der hier durch enormen Arbeitsaufwand komprimierte Informationsgehalt und die Namen der Autoren machen diesen Katalog zu einem Standardwerk der Blattlausforschung.

PETERSEN

Schwerdtfeger, F. Ökologie der Tiere. (Lehr- und Handbuch in drei Teilen). Band 1: Autökologie. Die Beziehungen zwischen Tier und Umwelt. 2., neubearbeitete Auflage. Verlag PAUL PAREY, Hamburg-Berlin. 1977; Lex. 8°; 460 S., 268 Abb., 55 Übersichten. Preis 120,00 DM.

Das dreiteilige Werk folgt dem Stufenbau des ökologischen Beziehungsgefüges: Der erste Band behandelt die Autökologie; der zweite Teil befaßt sich mit der Demökologie, den aus Angehörigen einer Art sich bildenden Populationen; Gegenstand des dritten Bandes ist die Synökologie, die Lehre von den aus mehreren bis vielen Arten zusammengesetzten Tiergemeinschaften. Jeder der drei Bände ist in sich abgeschlossen und auch ohne Kenntnis der anderen zu benutzen. – Der erste Band, in zweiter Auflage weitgehend neu bearbeitet, behandelt die Beziehungen des Tieres als Individuum oder Repräsentant seiner Art zu den Gegebenheiten der Umwelt. Vorangestellt ist eine kurze Erörterung der Grundlagen der Ökologie, insbesondere ihrer Grundbegriffe. Der eingehenden Schilderung der Tier-Umwelt-Beziehungen ist die Gliederung der Umweltkomponenten in abiotische, trophische und biotische Faktoren zugrundegelegt. Die Einflüsse der einzelnen Faktoren, beispielsweise des Lichtes, der Nahrungsmenge oder der Parasiten, auf den Bau, die Leistungen und das Verhalten des Tieres werden unter dem Gesichtspunkt dargestellt, die Relationen möglichst eindeutig zahlen- oder kurvenmäßig zu erfassen. Es ergibt sich so eine weitgehend quantitative Analyse der Tier-Umwelt-Beziehungen, die am Schluß ergänzt wird durch den Versuch, die Synthese der vielfältigen Einzelrelationen zum komplexen Tier-Umwelt-Gefüge zu vollziehen. – Die zweite Auflage, bei deren umfassender Bearbeitung kaum eine Seite unverändert geblieben ist, berücksichtigt die zahlreichen, zum Teil nachhaltigen neuen Erkenntnisse, die seit 1963, dem Erscheinungsjahr der ersten Auflage, in der Autökologie gewonnen worden sind. Das wesentliche Schrifttum ist bis einschließlich 1975 verarbeitet und in rund 1800 Zitaten nachgewiesen.

MORGE

DOI: 10.21248/contrib.entomol.30.1.9-14