

## A Further Note on the Use of the Terms *Instar*, *Stadium*, and *Stage*<sup>1</sup>

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**ABSTRACT** The *instar*, *stadium*, *stage* terminology is not an improvement to the original terminology because it ignores historical precedence and widely used standardized definitions. It is inconsistent and promotes the use of *stage* (as well as *stadium*) to mean the time period between successive ecdyses. A viable alternative to this terminology is to use *instar* and *stadium* in reference to either ecdysis or apolysis, although those using apolysis should clearly state or imply such usage. *Stage* should be restricted to refer to major and minor divisions of an arthropod's life cycle which are not strictly delimited by ecdyses or apolyses.

Ideally any terminology should succinctly name or describe the events, structures, or subjects to which it is assigned. Changes in thought concerning the relative significance of ecdysis and apolysis in the biology of insects have unfortunately clouded the meanings of *instar*, *stadium*, and *stage*—terms that refer to phases in the metamorphosis and growth of insects.

In 1853, Fischer proposed using the Latin term *instar*, meaning form or figure, to mean the form of the insect between successive ecdyses (molts). Fischer further proposed designating a number for each successive larval or nymphal *instar* so that each could be directly addressed. Thus, *instar* became the corollary of *stadium* and *stage*, terms already in use prior to 1853 to refer to the intervals, similarly numbered, between successive ecdyses (Sharp 1895). By the early 1900's *instar* began to gain acceptance (Folsom 1909) and by the 1930's was widely used (Folsom 1934). Today these meanings of *instar*, *stadium*, and *stage* are usually used and have become standardized in textbooks and dictionaries (Sharp 1895, Smith 1906, Folsom 1909, Packard 1909, Carpenter 1928, Needham 1928, Comstock 1930, Folsom 1934, Ross 1948, Urquhart 1949, Comstock 1950, Torre-Bueno 1978,<sup>2</sup> Ericson 1961, Richards and Davies 1964, Pennak 1964, Kenneth 1966, Oldroyd 1970, Callahan 1971, Chapman 1971, Steen 1971, Little 1972, Swan and Papp 1972, Wigglesworth 1972, Borrer et al. 1976, Horn 1976, Leftwich 1976, Gove 1976, Richards and Davies 1977,<sup>3</sup> Atkins 1978, Elzinga 1978, Gillott 1980). The Entomological Society of America (Anderson et al. 1971) has also recommended the same standard usage, except that *stage* may also mean one of the successive principal divisions in the life cycle of an arthropod such as the egg, nymph, and adult *stages*.

Problems with the *instar*, *stadium*, and *stage* terminology developed upon realizing that an *instar* physiologically begins and ends with apolysis (the separation of the old cuticle from the epidermal cells prior to se-

cretion of the new cuticle) rather than ecdysis (Snodgrass 1935, Hinton 1946, 1958, 1971, 1973, 1976, Jenkin and Hinton 1966, Passonneau and Williams 1953, Jones 1978). To incorporate the concept of apolysis into this terminology, Snodgrass (1935, p. 64) and later Jones (1978) redefined *instar* to mean the arthropod itself between successive apolyses, while *stage* and *stadium* remain defined as the life span of the animal between successive ecdyses.

Unfortunately the Snodgrass-Jones terminology is undesirable for several reasons. Foremost, it ignores historical precedence and widely used standardized definitions. It further ignores the strong likelihood that ecdysis will remain the developmental landmark of choice because, as Jones (1978) admits, "It is often impractical, difficult, or even impossible to tell precisely when apolysis has taken place in insects...." Therefore *instar* as originally defined remains a most useful term.

The Snodgrass-Jones terminology also creates a minor problem due to the inconsistency resulting from the arbitrary decision to define *instar* in reference only to apolysis while *stadium* or *stage* are defined in reference only to ecdysis. Since none of these terms can be used to refer either to the time interval between apolyses or to the form of an insect between ecdyses, some circumlocution becomes necessary, such as second *stadium* larva rather than second *instar*.

Finally, *stage* is not a desirable term to mean the time period between successive ecdyses because it has many alternate uses. *Stage* has been used to refer to major (e.g., egg, larva, adult) and minor divisions of the life cycle of an insect. For example, in many mayfly life-history studies it has been necessary to establish arbitrary distinct morphological *stages* in order to describe adequately the complex seasonal morphological development of the nymphs (e.g., Rawlinson 1939, Clifford 1970, McCafferty and Huff 1978).

The simplest alternative to the Snodgrass-Jones terminology is to retain and expand the original meanings of *instar* and *stadium* so both terms may be used in reference to ecdysis or apolysis. Essentially, *instar* and *stadium* naturally expanded in meaning when the importance of apolysis was later realized; their original meanings remain useful because ecdysis is still a more practical landmark in development. This is a viable alternative since most could continue using the terms as

<sup>1</sup>Received for publication 19 August 1981; accepted 4 February 1983.

<sup>2</sup>The date of Torre-Bueno (1978) is the date of the fifth printing. The effective date (i.e., latest update) of the dictionary is 1960, the date of Supplement A edited by G. S. Tulloch.

<sup>3</sup>In the tenth edition of Imm's General Textbook of Entomology, Richards and Davies state that *instars* are delimited by apolyses, but in many cases *instar* may be conveniently used in reference to ecdysis (see pp. 353-355; 363).

originally defined, while others seeking or requiring more precision in their work could use apolysis. Those using apolysis should clearly state or imply such usage, and *stage* should be restricted to referring to major and minor divisions of the life cycle as discussed above.

Another alternative involves the establishment of two complete sets of terms; one used only in reference to ecdysis and the other only in reference to apolysis. Unfortunately, because this requires the proposal and adoption of new terms (a long and uncertain process), it may be best to retain the original terminology as modified above. While this terminology may not be ideal, it surely is adequate if biologists remain acutely aware of such important concepts as apolysis, ecdysis, and the pharate or hidden individual.

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