# A DUAL BEHAVIORAL INTERPRETATION OF A SINGLE ENVIRONMENTAL STIMULUS WITH FRESHWATER MUSSELS

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The freshwater mussel is anatomically regressed in brain development and is without multicellular visual organs. There may not be enough neurological ability, or sensory input from external stimuli such as removal from water, physical vibrations carried through sand or mud, or shadows, for the clam to consistently be closed when the stimulus is harmful (predators, poisons), or opened in beneficial cases (food, improved aeration).

Evidence exists that a dual behavioral interpretation of a single environmental stimulus occurs in practice. Upon stimulation open mussels close and closed mussels remain closed. But within an hour all mussels open, even those closed before stimulation. Thus the clam first reacts as if it were in danger and then reacts as if the stimulus were caused by something beneficial once the chance of danger has decreased.

*Light*

Wenrich (1916), and earlier workers documented closing of most pelecypods when a light was turned off and in half the species when the light was turned on. Braun and co-workers (1954, 1965) caused *Anodonta* and *Unio* to close with very small light changes, provided an opaque shield was passed in front of the light source very slowly. Thus the mussel appears initially to interpret the light change as a shadow caused perhaps by a predator. I studied *Elliptio complanatus* in chambers with a photoperiod similar to natural conditions (Imlay, 1968). There is a doubling of the normal frequencies of opening within an hour after light onset and light termination. In short, there is an initial negative response to light change followed by a positive permanent response.

*Vibrations*

Anyone who has picked up a mussel is aware of the fast closing response. Barnes (1955) showed that *Anodonta* opens after a few minutes in response to slight vibrations. I likewise found (Imlay, 1968) that *Elliptio complanatus* opens within an hour after very slight mechanical disturbance. A violent disturbance also caused most of the closed mussels to open. However, not all the open mussels reopened following temporary closure. This constitutes an exception to the general dual behavioral interpretation.

*Water Change*

Gartkiewicz (1922) showed that water change caused opening of *Anodonta*. Woortman (1926) found that well aerated sea water caused *Mytilus* to open but poorly ventilated aquarium water caused closing. I found that *Elliptio complanatus* similarly opens or remains open after gentle water change without disturbance even if the original water is returned. *Amblema plicata* also opened following water change.

*Other Stimuli*

Gartkiewicz (1922) caused closed clams to open with electrical shocks. Barnes (1955) found that small or large changes in temperature did not cause opening.

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# THE EARLIEST NAMES FOR NORTH AMERICAN NAIADS


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In the time of Linnaeus 1758 there were muscles or mussels (*Mytilus*) marine and freshwater. Only a few freshwater mussels from North America had reached Europe early enough to be in Dr. Lister's 1685 picture book of shells. Perhaps the commonest species from Virginia was named [*Elliptio*] *complanatus* by Lightfoot in the Duchess of Portland Catalogue 1786. Gmelin in the 13th Edition of the Systema Naturae, 1791, named two more of Lister's figured species from Virginia [*Lampsilis*] *radiata* and [*Anodonta*] *fluviatilis.*

Spengler in 1793 renamed [*complanatus*] as *violaceus* and named another species *truncatus* to preoccupy a well known name of Rafinesque. Schumacher named the genus *Margaritifera* in 1816, but did not know it was also in North America.

It wasn't until Americans started studying the North American naiads that the names began to multiply, mirroring the much greater number of N. American species in contrast to very few in European waters. Thomas Say in the American Edition of Nicholson's Encyclopedia named several species including *alatus* and *costata* in 1817. Lamarck in 1819 named some of the common Mississippi drainage species including *ligamentina* and *luteola,* that had been sent back to France.

Rafinesque in 1818 named the genus *Potamilus* from the Ohio region; in 1819 he gave a generic outline or prodrome, and in 1820 published his "Ohio River Monograph." Unfortunately for the clarity of North American names, this was published in Brussels, in French, and was unnoticed by most American workers for some years. Rafinesque introduced 108 names (65 species and 43 varieties). He placed them in 23 generic groups, most of which we know today are biologically valid genera and subgenera.

The fog over the earliest names for North American naiads was laid down when Isaac Lea got steamed up in personal prejudice. Lea proved he knew Rafinesque's 1820 names when in 1829 he renamed one of the 3 homonyms created by Rafinesque. Barnes 1823, Valenciennes 1827, Hildreth 1828, Say 1829, Lea 1829, Swainson 1829, Say 1830, Lea 1830, and Say 1831 all published additional new names for North American species before Rafinesque in Nov. 1831 published his "Continuation of the Ohio River Monograph." In Dec. 1831 and later Isaac Lea ignored [professed ignorance of] and refused to accept any of Rafinesque's names that he could avoid in any way possible.

When Say and Conrad were sent copies of Poulson's 1832 translation of Rafinesque 1820, they published synonymies, accepting all the Rafinesquean names they could recognize from the very brief descriptions concerned. Férussac in 1835 printed his synonymy with paratypes from Rafinesque, and all of Isaac Lea's names in front of him.

The fog has continued over Rafinesque's and a few other names to the present, because some people are prejudiced against changing any part of their own status quo. As Rafinesque printed in 1820, "such naturalists cannot accept name changes made necessary by new discoveries." Bryant Walker in 1917 (Nautilus 20: 43–47) first stated and then for two pages tried to deny that Rafinesque had printed so many of his specific names under *Unio*. As a matter of simple fact many of Rafinesque's species and variety names of 1820 were printed under three generic names, and so preoccupy later names in all three genera. The binomials and trinomials of Rafinesque have been available to all since they were indexed in Binney and Tryon's 1864 reprint of Rafinesque's works on mollusks. On the other hand neither Simpson in 1900 and in 1914, nor Haas in 1969 have even listed or indexed all of the earliest names.

The efforts of Ortmann, Walker, and Pilsbry (1922) to straighten out many tangles of synonymy are seriously incomplete for two reasons. The then incomplete crystallization of the international rules allowed them to decide against first priority of dates and type-species fixations. Secondly they did not approach Rafinesque's monograph with all the Ohio and Kentucky species laid out, to determine what Rafinesque called each form. In other words they did not attempt to fix all of Rafinesque's names, but took only selected adult ones under study.

The first step out of the fog is a complete indexing of all early naiad names, particularly those published before the December 1831 work of Isaac Lea. The second step is the adoption of the earliest name for each taxon without prejudice against priority. To stay out of the fog we must use names that are not preceded by any other for the same biological taxonomic entity. If we do not accept the names of the accompanying list, the next critical student to follow can do so, and truthfully say we were not quite scientific enough.

*Lasmigona badia* Raf. 1831 (= *holstonia* Lea 1838)
*Alasmidonta viridis* Raf. 1820 (=*calceola* Lea 1829)

*Alasmidonta atropurpureum* Raf. 1831 (= *raveneliana* Lea 1834)
*Fusconaia lateralis* Raf. 1820 (= *undata* Barnes 1823)
*Fusconaia pusilla* Raf. 1820 (= *ebena* Lea 1831)
*Fusconaia polita* Say 1834 (= *subrotunda* Lea 1831 preocc.)
*Megalonaias nervosa* Raf. 1820 (= *gigantea* Barnes 1923)
*Quadrula bullata* Raf. 1820 (= *pustulosa* Lea 1831)
*Plethobasus pachosteus* Raf. 1820 (= *cicatricosus* Say 1829)
*Plethobasus striatus* Raf. 1820 (= *cooperianus* Lea 1834)
*Pleurobema obliquata* Raf. 1820 (= *pyramidatus* Lea 1834)
*Pleurobema obliquum* Lamarck 1819 (= *cordatum* Raf. 1820)
*Pleurobema sintoxia* Raf. 1820 (= *solidum* Lea 1838)
*Pleurobema premorsa* Raf. 1831 (= *plenum* Lea 1840)
*Cyprogenia stegaria* Raf. 1820 (= *irrorata* Lea 1829)
*Ellipsaria ligamentina* Lamarck 1819 (= *carinata* Barnes 1823)
*Crenodonta lineolata* Raf. 1820 (= *securis* Lea 1829)
*Truncilla vermiculata* Raf. 1820 (= *truncata* Raf. 1820 preocc.)
*Potamilus alatus* Say 1817 (monotype of *Potamilus* in 1818)
*Potamilus ohiensis* Raf. 1820 (= *laevissima* Lea 1829)
*Toxolasma livida* Raf. 1831 (= *glans* Lea Dec. 1831)
*Lemiox rimosus* Raf. 1831 (= *caelatus* Conrad 1834)
*Villosa teneltus* Raf. 1831 (= *taeniata* Conrad 1834)
*Lampsilis teres* Raf. 1820 (= *fallaciosa* Smith 1899)
*Lampsilis luteola* Lamarck 1819 (= *siliquoidea* Barnes 1823)
*Lampsilis cardium* Raf. 1820 (= *ventricosa* Barnes 1823)
*Lampsilis abruptus* Say 1831 (= *orbiculatus* Lea not Hildreth 1828)
*Plagiola interruptus* Raf. 1820 (= *brevidens* Lea 1831)
*Plagiola ridibundus* Say 1831 (= *sulcatus* Lea 1829 preocc.)
*Plagiola perobliqua* Conrad 1837 (= *delicata* Simpson 1900)
(*Epioblasma*) *flexuosa* Raf. 1820 (= *foliata* Hildreth 1828)

## EARLY WORKERS ON THE NORTH AMERICAN NAIADS

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There is a rather imposing list of people who were interested in the rich naiad fauna of North America. Prior to 1800 only a very few species had been described, and these few were described by European zoologists. Thomas Say's article on conchology in the American edition of Nicholson's British Encyclopedia of 1817 was the first report by an American worker to appear in the United States. Shortly thereafter Rafinesque, a European who had been appointed Professor of Botany and Natural History in Transylvania University of Lexington, Kentucky, started to publish on freshwater mollusks of the Ohio River system. Since this early beginning there have been many who have left a heritage of material and publications regarding this important group of mollusks.

There are four rather distinct categories which form a basis for our present knowledge of this group: 1. the collectors such as T. Say, H. H. Smith, A. E. Ortmann and a host of others who had brought together much of the material upon which later studies were based; 2. the describers such as T. Say, Isaac Lea, J. G. Anthony and others who made known by the printed page the existence of the genera and species of naiads; 3. the monographers such as T. Conrad, I. Lea, C. T. Simpson who brought together in systematic order the vast amount of isolated data which had accrued during the early history of this group; 4. the geographic monographers such as T. Say, T. Conrad, R. E. Call, B. Walker, and A. E. Ortmann who worked out the patterns of distribution of the various genera and species composing the freshwater mussels of North America.

EFFECTS OF POLLUTION ON THE NAIADS OF THE ILLINOIS RIVER. William C. Starrett, Illinois Natural History Survey, Havana, Illinois.

(no abstract submitted)

## EGG CASES OF *NITIDELLA OCELLATA* GMELIN AND AN *ANACHIS*

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A single adult specimen of *Nitidella ocellata* Gmelin was taken in the Key Vaca area of the Florida Keys November 26 or 27, 1968 and kept in an aerated container of sea water with several other mollusks. On January 10, 1969 egg cases were discovered, having been deposited in concealed areas such as niches in coral rocks and in the hinge sockets of clam shells. Deposits continued at intervals until mid-February with a total of twenty cases, none of which were observed at the time of deposit. The egg cases were sturdy yellowish bulbs, globular-oval, 1.5 mm long, firmly attached to the substrate at a 1 mm base plus a narrow, irregular rim. The thinner hatch area (comparatively large for the size of the case) was 1 mm in length, situated off center, rather saddle shaped, and characterized by a flaring collar. In the twenty cases found, the number of yellowish eggs varied from eight to fourteen at best count without dissection. However, no more than three embryos developed beyond the veliger stage in any one case, and no more than two juveniles hatched crawling from a single case, the third (and/or second) veliger being either underdeveloped or its shell crushed as the case became crowded.

Time of incubation was not determined but it is apparently rather long, as two cases that when discovered contained moving embryos did not hatch their crawling young until 49 days later. The smooth dark brown shell of the newly hatched averaged .8 mm in height and was about ⅔ at the overall widest. Having rasped and pushed their way through the hatch area, the young fed almost immediately on tiny crushed mussel spat (*Mytilus edulis* Linné). At three days there was new growth, showing two rows of the white spots that are characteristic of *Nitidella ocellata*.

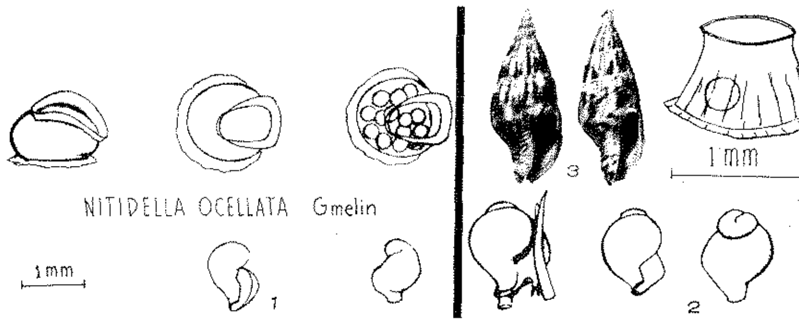


Fig. 1 Egg case and young of *Nitidella ocellata*
Fig. 2 Egg case and young of *Anachis* sp.
Fig. 3 *Anachis* sp. C. 1X

No egg cases were discovered after mid-February, 1969. Twelve specimens survive, in age to five months and in size to 10 mm and are being kept for further live observation.

Ten specimens of another columbellid were also collected in November, 1968 from the low intertidal zone of a rocky area at Grassy Key, in the Florida Keys. Four specimens survived in captivity for several months. The shell of this columbellid resembles that of *Anachis*, as does the dark animal, its behavior, and the fact that it is a carnivore. As proper identification of the species has not been made, the term "*Anachis*" is pro tem for the purposes of this report. A limited search of the literature and inquiry of a few workers in the field have as yet produced no clues.

Adults of this *Anachis* are 7½ to 9 mm in height, 3+ to 3.5 mm wide; the aperture is less than half the height; the columella is smooth. There are seven whorls, a smooth protoconch and the later whorls with low ribs which number about fifteen at the last whorl, very slightly keeled at sutures. The color is variable, ranging from a very light yellowish tan in some specimens through intermediate shades to quite dark brown in others, all well splotched with cream. The thin, tan, corneous operculum is small and perched near the posterior end of the foot. The structure of the egg cases, averaging 1 mm in height and width, also fits into the general pattern of *Anachis* cases, being shaped somewhat like an opera hat—with more or less perpendicular sides capped by the hatch which is sealed with a very narrow rim, barely projecting over the sidewall of the almost cylindrical case.

From February to mid-July approximately 200 cases were deposited by the two or three females in the aquarium. Each case held a single egg save one case which held two eggs. These two eggs did not develop to maturity.

Incubation ranged from 25 to 32 days when the fully developed young specimen, almost filling its case, spent at least a day rasping around the rim of the hatch area to emerge crawling. Average size of a newly hatched was .7 mm high and .5 mm wide, with the apertural edge so curved as to protrude slightly at its center. This protrusion was still evident at 3+ months and 5 mm in length but is not present in the adults.

These newly hatched were also fed on very tiny, crushed mussel spat (*Mytilus edulis* Linné).