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# *Brachydeutera longipes* Hendel, 1913 a major component of macroneuston in a purification lagoon in French Guiana [Diptera, Ephydridae]

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Keywords: Diptera, larvae and pupae, neotropical region, purification lagoon, prolification.

*B. longipes* is very abundant in the surface film of three ponds of a large purification lagoon near Cayenne, French Guiana. The larvae and pupae are part of the hyponeuston, while the adults whirl round at the water surface and belong to the epineuston. Larvae and pupae make up between 21.6 % to 99.5 % of the total macroneuston in terms of numbers. The surface pellicle consists mainly of some fine mud particles, Chlorophyceae, fragments of Graminae, and *Lemna* sp. Bioecological parameters in the purification lagoon are highly unfavourable: the water temperature can exceed 35°C, $NH_4^+$ 15 mg/L, and $Cl^-$ 35 mg/L. $O_2$ can fall below 10% of saturation, and pH is highly unstable, varying at least between 6.9 and 10.0 over a 24 hour period. Floatation occurs in spite of surfactants (total P concentration can exceed 33 mg/L).

Hydrophobic ornamentation of the cuticle and terminal spiracles were photographed with SEM.

The rare records of *B. longipes* from the USA (Georgia, Maryland and N Carolina) appear to be the northern limit of its distribution in the Nearctic. This species is probably not a recent introduction from the Oriental region as previously suspected (MATHIS & STEINER 1986). The present record, new for French Guiana and for South America, shows up the lack of knowledge of non-biting Diptera faunistics in America South of Mexico.

## *Brachydeutera longipes* Hendel, 1913 un composant majeur du macroneuston dans une lagune d'épuration en Guyane Française [Diptera, Ephydridae]

Mots-clés : Diptera, larves et pupes, région néotropicale, bassins de lagunage, prolifération.

*B. longipes* est très abondant dans le film de surface des trois bassins d'une grande lagune d'épuration près de Cayenne, Guyane Française. Les larves et les pupes font partie de l'hyponeuston, tandis que les adultes tourbillonnent à la surface et appartiennent à l'épineuston. Larves et pupes constituent entre 21,6 % et 99,5 % du macroneuston total en termes d'effectifs. La pellicule de surface est principalement formée de fines particules de boue, de Chlorophyceae, et de fragments de Graminae, ainsi que de *Lemna* sp. Les paramètres bioécologiques sont très défavorables dans cette lagune : la température de l'eau peut excéder 35°C, $NH_4^+$ 15 mg/L, et $Cl^-$ 35 mg/L. Le contenu en $O_2$ peut s'abaisser au dessous de 10% de la saturation, et le pH est très instable, variant au moins entre 6.9 et 10.0 sur un cycle de 24 heures. La flottaison a lieu en dépit des surfactants (la concentration en P total peut excéder 33 mg/L).

L'ornementation hydrophobe de la cuticule et les stigmates terminaux ont été photographiés au microscope électronique à balayage.

Les rares citations de *B. longipes* des USA (Géorgie, Maryland et Caroline du Nord) apparaissent être la limite septentrionale de sa distribution en région Néarctique. Cette espèce n'est probablement pas une récente introduction venant de la région Orientale, comme il a été présumé (MATHIS & STEINER 1986). La présente citation, nouvelle pour la Guyane Française et pour l'Amérique du Sud, met en particulier l'accent sur le manque de connaissances en général sur la faunistique des Diptères non vulnérants en Amérique, au Sud du Mexique.

## 1. Introduction: the neuston

"Animals and plants living at the [water] surface are members of the community known as the neuston. Those which live above the water but in regular contact with it make up the epineuston, and those hanging down from the surface are the hyponeuston" (GUTHRIE 1989).

MCCAFFERTY & THOMAS (1994) did not agree with the substitution of "pleuston" for the more generally used "neuston" by WARD (1992), preferring to distinguish "micro" and "macro" neuston (in the same way it is done for benthos).

The two major works of BAUDOIN (1955, 1976) deal with physico-chemistry of the water surface and neuston biology.

We had the opportunity to study the neuston of a purification lagoon in French Guiana, where we collected an abundant population of *Brachydeutera longipes* (Ephydridae).

## 2. The biotope

A purification lagoon was designed for the treatment of waste water from the Matoury city (4,000 inhabitants), near Cayenne, French Guiana. Waste waters were pouring directly into a marsh; they now settle in three successive oxidation ponds (respective areas: 0.8, 0.5 and 0.5 ha) (Map 1) before flowing into the marsh. During the study, the bottom of these recent ponds was devoid of mud.

Water analyses were carried out with field WTW devices (including a spectrophotometer WTW 3000) on 3-VII-1996 (wet season) and 26-VIII-2006 (dry season).

Table 1 summarizes instantaneous values of main physico-chemical parameters in the oxidation ponds and in the marsh. The daily range of $O_2$ content and of pH in the input and in the three oxidation pond outputs is given in Table 2.

Parameters of waste waters pouring into the purification lagoon (input: Fig. 1) are highly unfavourable, for example (Table 2):

- 3-VII-1996: dissolved $O_2$ ranged from 3 to 17 % of saturation at 29°C, and conductivity from 499 to 664 µS/cm, in spite of the very low natural ionic content of most Guianese streams and rivers;
- Tables 1 and 2 show:

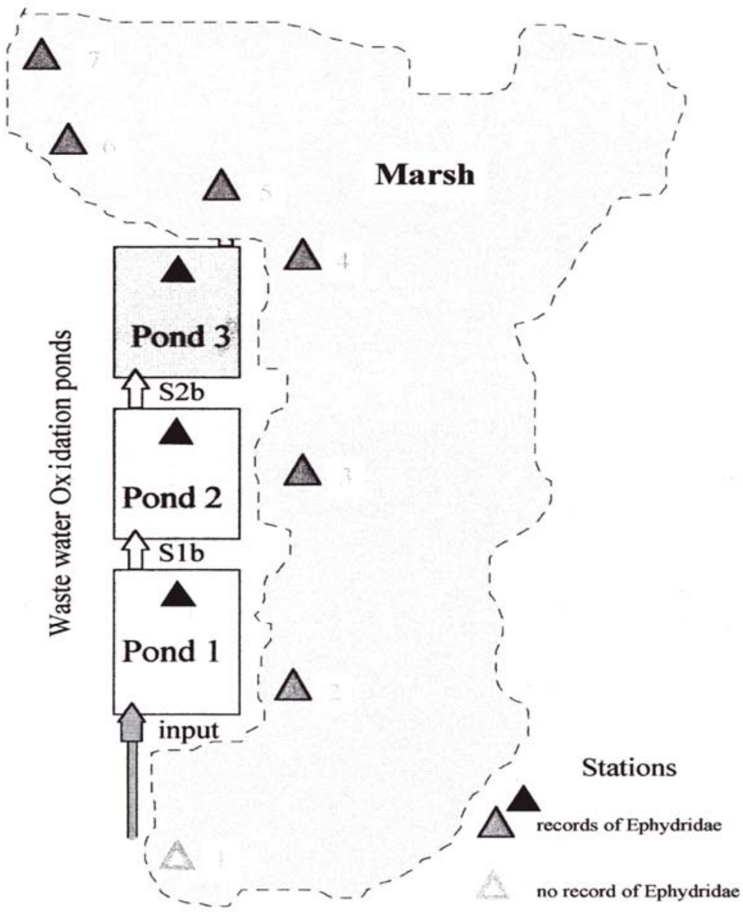


Figure 1. The oxidation basins and marsh of Matoury, near the city of Cayenne

Figure 1. Les bassins de lagunage et le marais récepteur de Matoury, près de la ville de Cayenne

- the hard bioecological conditions in both the oxidation ponds and the marsh in terms of extremes;

- and besides, the great instability of several important physico-chemical parameters between the two series of measures -beginning of July and late August- (Table 1) and also within a very short time -24 hours- (Table 2), partly due to the intense insolation (fast algal growth) and to the frequent strong tropical storms impacting the water surface.

Moreover (Table 1) the differences between sites in the marsh are important due to bottom heterogeneity, with local accumulations of decaying leaves according to the riparian tree cover, and also the presence of several other domestic wastes… pouring into the marsh without control. So, considerable variations in nutrients are induced locally.

Nevertheless, with regard to the lagoon efficiency in terms of purification, the rise in *maximal* $O_2$ content between the input and the three pond outputs is considerable (Table 2).

| **Water parameters** | Conductivity (µS/cm) | | Susp. Solids (mg/L) | | Chlorophyll (µg/L) | | $Cl^-$ (mg/L) | | COD (mg/L) |
|---|---|---|---|---|---|---|---|---|---|
| STATIONS | 03-VII | 26-VIII | 03-VII | 26-VIII | 03-VII | 26-VIII | 03-VII | 26-VIII | 26-VIII |
| Waste water ponds | | | | | | | | | |
| output of pond 1 | 315 | 375 | 66 | 4 | 400.4 | 758.9 | 25 | 37 | 20.4 |
| output of pond 2 | 235 | 317 | - | 11 | 414.7 | 719.8 | - | 36 | 16.9 |
| output of pond 3 | 220 | 285 | 26 | 13 | 381.4 | 677.1 | 20 | 34 | 18.3 |
| Marsh | | | | | | | | | |
| station 2 | 234 | 130 | 68 | 15 | 75.2 | 65.5 | 12 | 13 | 4.0 |
| station 3 | 115 | 141 | 34 | 2 | 61.6 | 81.8 | 8 | 19 | 6.1 |
| station 4 | 200 | 324 | 202 | 17 | 258.7 | 580.6 | 17 | 36 | 16.1 |
| station 5 | 217 | 311 | 183 | 16 | 667.5 | 655.2 | 20 | 35 | 16.5 |
| station 6 | 203 | 160 | 26 | 5 | 68.1 | 201.5 | 18 | 19 | 15.1 |
| station 7 | 32 | 31 | 17 | 10 | 54.2 | 77.7 | 4 | 9 | 18.5 |

| **Water parameters** | O2 (% sat) | | N-NH4 (mg/L) | | N-NO3 (mg/L) | | P-PO4 (mg/L) | | Total P (mg/L) |
|---|---|---|---|---|---|---|---|---|---|
| STATIONS | 03-VII | 26-VIII | 03-VII | 26-VIII | 03-VII | 26-VIII | 03-VII | 26-VIII | 26-VIII |
| Waste water ponds | | | | | | | | | |
| output of pond 1 | 23 | 280 | 13.0 | 11.1 | 1.5 | 3.0 | 4.28 | 5.31 | 13.36 |
| output of pond 2 | 170 | 283 | 8.0 | 7.6 | 0.8 | 3.3 | 3.26 | 5.32 | 8.50 |
| output of pond 3 | 130 | 380 | 6.6 | 5.1 | 0 | 4.4 | 3.32 | 5.23 | 8.40 |
| Marsh | | | | | | | | | |
| station 2 | 3 | 48 | 18.6 | 5.9 | 0.7 | 2.8 | 0 | 0.06 | 0.68 |
| station 3 | 4 | 40 | 5.0 | 4.3 | 1.2 | 4.0 | 0.03 | 0.06 | 0.48 |
| station 4 | 23 | 25 | 7.9 | 1.5 | 0.5 | 3.7 | 3.75 | 5.37 | 8.28 |
| station 5 | 20 | 55 | 7.3 | 1.4 | 0 | 4.2 | 3.88 | 5.34 | 33.36 |
| station 6 | 18 | 5 | 10.1 | 1.1 | 0.5 | 2.2 | 3.19 | 1.02 | 7.44 |
| station 7 | 22 | 3 | 0.2 | 0.1 | 0.3 | 3.4 | 0.05 | 0.02 | 0.18 |

Table 1. Physico-chemical parameters in the oxidation ponds and its marsh (stations where *B. longipes* is present). 3-VII = wet season; 26-VIII = dry season.

Tableau 1. Paramètres physico-chimiques dans les bassins de lagunage et dans le marais (stations où *B. longipes* est présente). 3-VII = saison humide ; 26-VIII = saison sèche.

| **Water Parameters** | O2 (% of saturation) | | | Temperature (°C) | | | pH | | |
|---|---|---|---|---|---|---|---|---|---|
| | Min. | Max. | Time (h) | Min. | Max. | Time (h) | Min. | Max. | Time (h) |
| STATIONS | | | | | | | | | |
| Input | 3 | 17 | 17 | 28.9 | 35.0 | 17 | 6.8 | 7.3 | 10 |
| Waste water ponds | | | | | | | | | |
| output of pond 1 | 11 | 250 | 15 | 28.9 | 34.6 | 17 | 6.8 | 8.6 | 17 |
| output of pond 2 | 23 | 416 | 15 | 29.0 | 35.6 | 15 | 6.9 | 9.5 | 15 |
| output of pond 3 | 8 | 425 | 12 | 29.0 | 39.0 | 15 | 6.9 | 10.0 | 15 |

Table 2. Three main parameters in the input and in the three treatment ponds: daily range (3-VII-1996).

Tableau 2. Variation journalière (le 3-VII-1996) de trois paramètres principaux en entrée de station et à la sortie des trois bassins de lagunage.

## 3. The animal communities and *B. longipes*

The lagoon surface pellicle consists mainly of some fine mud particles, Chlorophyceae, fragments of Graminae, and *Lemna* sp. making patches at water/air interface, which move with the wind.

The animal communities were sampled also on 3-VII and 26-VIII-1996 with hand nets (mesh size = 200 µm). They belong to zooplankton in the water column, and to macroneuston at the water surface.

Aquatic instars and adults of *Brachydeutera longipes* were collected in the three oxidation ponds, and also in the marsh at 6 stations out of 8 (st. 2, 3, 4, 5, 6 and 7: Fig.1). Though air-breathers, the larvae and pupae, are part of the hyponeuston, while the adults, very active, whirl round at the water surface and belong to the epineuston. The adults were determined using the key to genera of Ephydridae by WIRTH et al. (1987), the key to species and especially the figures of genitalia by MATHIS & GHORPADÉ (1985).

Larvae and pupae of *B. longipes* are a major component of neuston in the study area: up to 90 % in terms of numbers of individuals in the ponds (Table 3) and up to 50 % in the marsh (Table 4). However, population dynamics of this species appears unstable: no larvae and/or pupae were sampled in the marsh during the wet season; and also, in the oxidation pools, larvae and/or pupae were much more abundant during the dry season than during the wet season. This is possibly due to the frequent physical perturbations at the water surface, storm after storm, during the wet season.

## Discussion

Table 3 shows a relatively low systematic diversity in the oxidation ponds, in accordance with the main ecological peculiarities summarized by GUTHRIE (1989): “The surface water undergoes greater fluctuations in temperature than either air or deeper water. Neuston will also be exposed to large amounts of solar radiation, especially ultraviolet wavelengths, which are potentially harmful. These may prevent some organisms from surviving at the surface, or may determine the times at which others are found there. The neuston occupies a niche in which it is difficult to survive, and includes a limited range of organisms, requiring very specialised adaptations of structure and behaviour."

| SAMPLING DATES | 3-VII-1996 (wet season) | | | 26-VIII-1996 (dry season) | | |
|---|---|---|---|---|---|---|
| Output of oxidation ponds | S1b | S2b | S3b | S1b | S2b | S3b |
| **Zooplankton** | | | | | | |
| Daphniidae | 600 | 3000 | 1660 | 9485 | 9300 | 9000 |
| Ostracoda | 130 | 1300 | 1100 | 2371 | 3000 | 2000 |
| **Macroneuston** | | | | | | |
| Oligochaeta | 1 | | | 2 | | |
| Planorbidae | | 2 | | | | |
| Dytiscidae | | 2 | 5 | | | |
| Hydrophilidae | | 1 | 1 | 1 | | |
| Coleoptera indet. | 1 | 1 | | 1 | | |
| Culicidae: larvae | | 9 | 10 | | | |
| Culicidae: nymphs | | 3 | 1 | | | |
| Chironomini: larvae | 1 | 20 | 8 | 1 | 2 | |
| Chironomini: nymphs | | 4 | 3 | | 1 | 1 |
| Ceratopogoninae | | | 1 | | | |
| Stratiomyiidae | | 1 | | | | |
| Empididae | | 3 | | | | |
| Phoridae | | 1 | | | | |
| ***B. longipes*: larvae** | **3** | **8** | **8** | **325** | **3** | |
| ***B. longipes*: pupae** | **1** | **7** | | **295** | | |
| Drosophilidae | | 1 | | 1 | | |
| Diptera indet. | | | | | 1 | |
| *Brachydeutera longipes*: percentage of neuston | 57.1 | 23.8 | 21.6 | 99.5 | 50.0 | - |

Table 3. The fauna of the three pond outputs (mesh size of nets: 200 µm).

Tableau 3. La faune à la sortie des trois bassins (vide de maille des filets : 200 µm)

| SAMPLING DATES<br>Marsh stations | 3-VII-1996 | 26-VIII-1996<br>2 | <br>3 | <br>4 | <br>5 | <br>6 | <br>7 |
|---|---|---|---|---|---|---|---|
| **Zooplankton** | | | | | | | |
| Daphniidae | n | 200 | 1860 | 470 | 369 | 2149 | 208 |
| Copepoda Cycloida | o | 150 | 610 | | | 268 | 210 |
| Ostracoda | | 50 | 124 | 490 | 738 | 269 | 313 |
| **Macroneuston** | r | | | | | | |
| Hydridae | e | | 16 | | | | 2 |
| Planaria | c | | 2 | | | | 1 |
| Nematoda | o | | 1 | | 2 | | 1 |
| Oligochaeta | r | 3 | 620 | 57 | 13 | 201 | 87 |
| Acheta | d | 1 | | | | | |
| Planorbidae | s | | 11 | | | 7 | |
| Anisoptera | | 1 | | | | | |
| Naucoridae | o | | 5 | | | | |
| Notonectidae | f | | 5 | | | | 4 |
| Pleidae | | | | | | | |
| Mesoveliidae | *B* | | | | | | |
| Heteroptera indet. | *r* | 19 | 26 | 14 | | 55 | 9 |
| Dytiscidae | *a* | 6 | 13 | 6 | | 15 | 2 |
| Hydrophilidae | *c* | 1 | 1 | | 2 | 1 | 3 |
| Scirtidae | *h* | 4 | | | | 1 | 1 |
| Coleoptera indet. | *y* | 2 | 7 | 1 | | 1 | |
| Culicidae | *d* | 8 | 33 | 88 | 1 | 71 | 23 |
| Tanypodinae | *e* | 2 | 11 | | | | |
| Corynoneurinae | *u* | | 11 | | | | |
| Chironominae | *t* | 1 | 23 | 19 | 69 | 93 | 142 |
| Orthocladiinae | *e* | | | | | | |
| Ceratopogoninae | *r* | | 2 | | | 1 | |
| Stratiomyiidae | *a* | | | | 3 | 2 | 1 |
| Syrphidae | | | 1 | | | | |
| ***B. longipes*: larvae** | i | **9** | **9** | **42** | **1** | **2** | **1** |
| ***B. longipes*: pupae** | n | **39** | **2** | **1** | **8** | | **1** |
| Muscidae | | | | | | | |
| Diptera indet. | J | | | 7 | | 2 | |
| Macroneuston: total numbers | u | 96 | 799 | 235 | 99 | 452 | 278 |
| *Brachydeutera longipes*:<br>percentage of neuston | l<br>y | 50.0 | 1.4 | 18.3 | 9.1 | < 0.01 | < 0.01 |

Table 4. The marsh fauna (mesh size of nets: 200 µm).

Tableau 4. La faune du marais (vide de maille des filets : 200 µm).

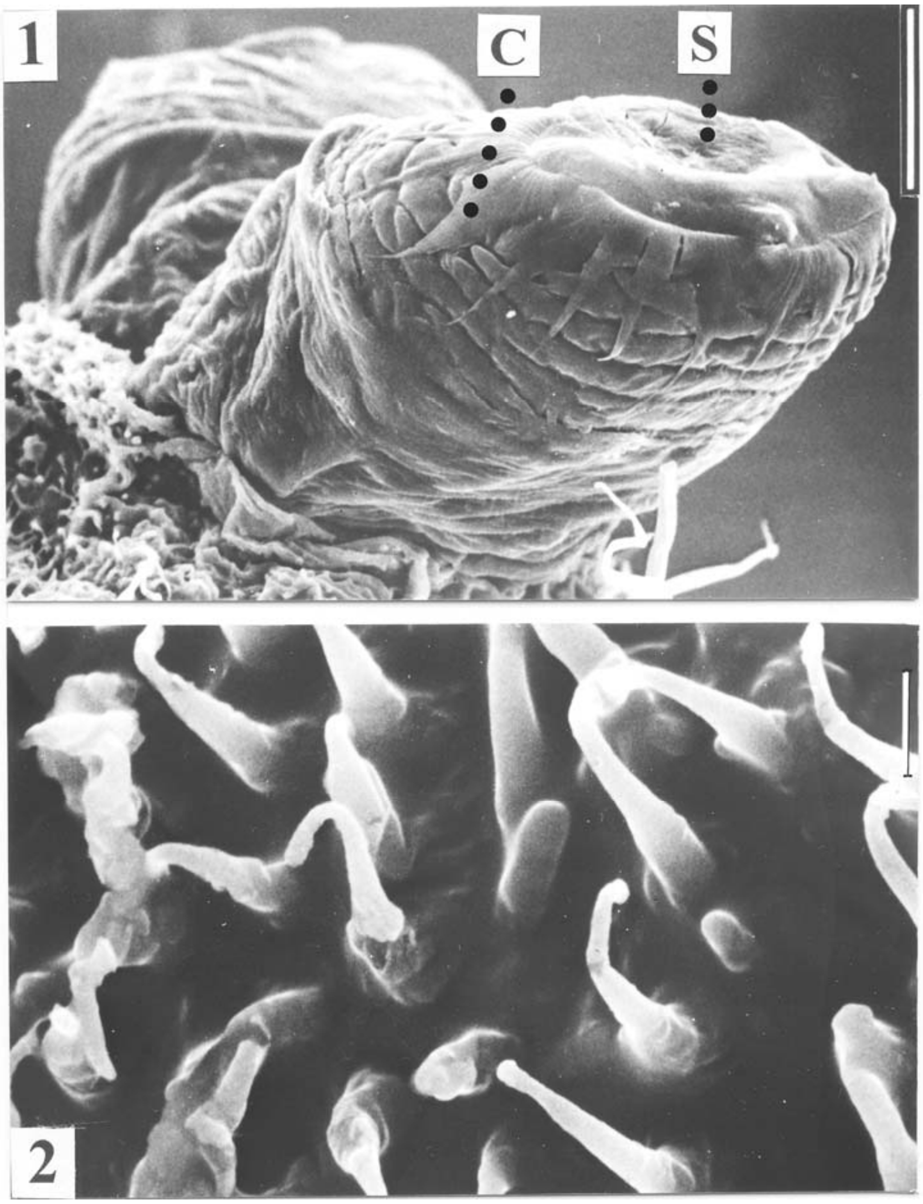


Figure 2. Larval structures of *B. longipes.* Photo 1: terminal spiracle of last-instar (S) and its crown (C) of hydrophobic projections (laid on integument by metal-coating); bar = 50 µm. Photo 2: hydrophobic integument (last abdominal tergum); bar = 5 µm.

Figure 2. Structures larvaires de *B. longipes*. Photo 1 : stigmate terminal du dernier stade (S) et sa couronne (C) de projections hydrophobes (plaquées contre le tégument par la métallisation) ; échelle = 50 µm. Photo 2 : tégument hydrophobe (dernier tergite abdominal) ; échelle = 5 µm.

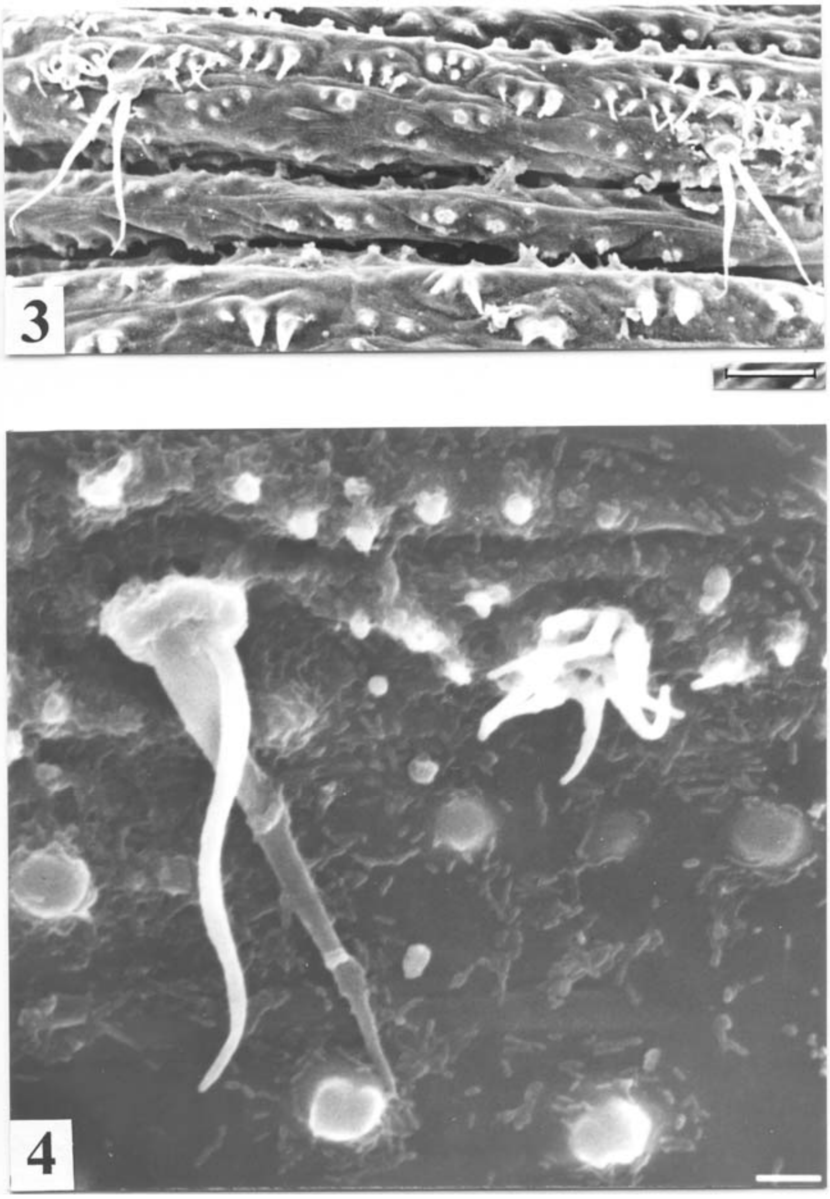


Figure 3. Larval structures of *B. longipes*. Photo 3: integument of last-instar (twin setae of second abdominal tergum); bar = 50 µm. Photo 4: detail of thoracic twin setae and sensillae; bar = 5 µm.

Figure 3. Structures larvaires de *B. longipes*. Photo3 : tégument du dernier stade (soies doubles du second tergite abdominal) ; échelle = 50 µm. Photo 4 : détail de soies doubles et sensilles thoraciques ; échelle = 5 µm.

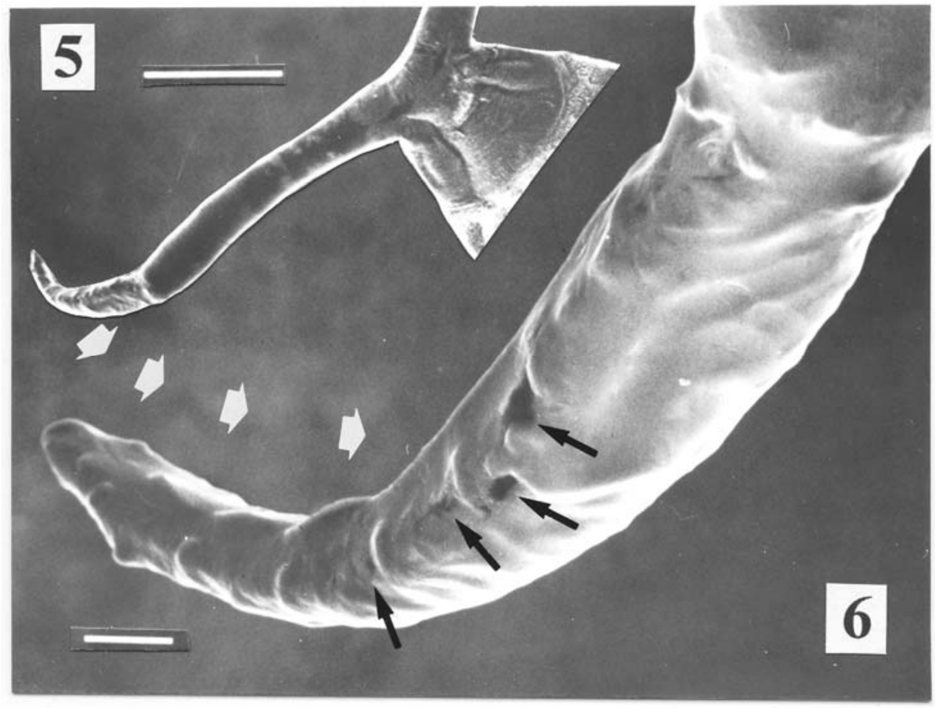


Figure 4. Pupal structures of *B. longipes*. Photo 5: left respiratory organ; bar = 500 µm. Photo 6: enlargement of distal segment (black arrows = respiratory apertures); bar = 50 µm. SEM, Paul Sabatier University.

Figure 4. Structures de la pupe de *B. longipes*. Photo 5 : corne respiratoire gauche ; échelle = 500 µm. Photo 6 : détail du segment distal (flèches noires = ouvertures respiratoires) ; échelle = 50 µm. Microscope électronique à balayage, Université Paul Sabatier.

On the other hand, at the surface, oxygen is freely available from the air and abundant nutrients come up from below or fall in from above.

Two species of Ephydridae (*Hydrellia griseola* and *Ephydra riparia*) are very common in unpolluted neuston (GUTHRIE 1989). Generally speaking, this family of Brachycera Cyclorrhapha (see MATILE 1993 for a comprehensive discussion of Diptera classification) numbers more than 1300 described species, "of which 425 and 68 genera occur in the Nearctic region" (WIRTH et al. 1987). Allied to the Drosophilidae, it is clearly more common in aquatic biota, and so, it is frequent in maritime grass pools, sand and rock pools, *Lemna* pools, and reed and Nymphaeid vegetation (DAHL 1959). 52 species living in still freshwater are listed in the 2nd edition of Limnofauna Europaea (DAHL 1978); several species inhabit maritime marshes (e.g., *Ephydra* spp.). Many species are leaf and/or stem miners on Aquatic Angiosperms (e.g., *Hydrellia* spp.).

The fly of *Brachydeutera longipes* was recorded around open sewage and septic tanks in India (see MATHIS & STEINER 1986, reporting interesting local observations by Venkatesh and coll.); in particular, the life cycle is very short: between 6 and 20 days, taking advantage of considerable pollution; larvae and pupae occur preferentially in aquatic weeds.

The present study confirms these data.

Several water parameters reached very high values during the sampling of larvae and/or pupae of *B. longipes*, pointing out the exceptional polluotolerance of this species:

- temperature: 39.0 °C;
- pH: 10.0 (falling to 6.9 within a 24 hour cycle);
- $O_2$ (percent saturation): 3 at 25.9 °C;
- $Cl^-$: 37 mg/L;
- $N\text{-}NH_4$: 13 mg/L;
- Total P: 33.36 mg/L, not preventing floatation of aquatic instars.

The body of both larvae and pupae is covered with hydrophobic structures, mainly developed on posterior end (Photo 2, Fig. 2), and respiratory tubercles bear a crown of hydrophobic projections (C, Photo 1, Fig. 2). Posterior margin of terga with spines. Presence of a pair of twin long setae on each tergum (Photos 3 and 4, Fig. 3).

The two-segmented thoracic respiratory organs of pupa are different from those of the common species in North America: *B. argentata* (Walker, 1852). According to figures (111-112, pl. X) and description (pp. 56-57) by JOHANNSEN (1935), the distal segment in *B. argentata* is as long as the basal segment, and leaf-shaped, "much flattened". In *B. longipes*, the distal segment is comparatively much reduced (Photo 5, Fig. 4), half the length of basal segment; it is digitiform, progressively tapering to the apex, with dorso-lateral respiratory apertures (Photo 6, Fig. 4).

## 4. Biogeography of *B. longipes*

The distribution of *B. longipes* in the Oriental region (WIRTH 1964, MATHIS & GORPADÉ 1985) includes: Cambodia, China, India, Indonesia, Japan, Malaysia, Pakistan, Philippines, Singapore, Sri Lanka, Taiwan, Thailand, Vietnam. A record in the Near East (Iraq) remains doubtful (MATHIS & GORPADÉ, op. cit. p 18).

Recent captures of adults at black light in some eastern states of the USA (Georgia, North Carolina and Maryland led to the hypothesis that the occurrence of *B. longipes* in this country is an introduction (eggs or immatures accompanying shipment of aquatic plant material to the U.S.: MATHIS & STEINER 1986).

The present record of *B. longipes* is new for French Guiana, and also for South America. First of all, it shows the basic lack of knowledge of Diptera faunistics in South America, with the exception of hematophagous families. So, we think that *B. longipes* is probably not an adventive species in the U.S.A. Its distribution is that of a tropical species (presently recorded only in the Northern Hemisphere), uncommon in the U.S.A. (in particular northwards, in Maryland: MATHIS & STEINER, op. cit., p 58), hence its late discovery there, during the eighties.

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**References**

BAUDOIN, R. 1955. La physico-chimie des surfaces dans la vie des Arthropodes aériens des miroirs d'eau, des rivages marins et lacustres et de la zone intercotidale. *Bulletin biologique de la France et de la Belgique*, **86** : 16-164.

BAUDOIN, R. 1976. Les insectes vivant à la surface et au sein des eaux. Pp 843-926 in : P.P. Grassé (éd.) *Traité de Zoologie*, **8**. Lechevalier, Paris.

DAHL, R. 1959. Studies on Scandinavian Ephydridae (Diptera, Brachycera). *Opuscula Entomologica*, suppl. **15**: 1-225.

DAHL, R. 1978. Ephydridae. Pp 482-484, in *Limnofauna Europaea*, J. Illies (ed.), Gustav Fisher Verlag, Stuttgart.

GUTHRIE, M. 1989. *Animals of the surface film*. Naturalists' Handbook n° **12**. 87 pp. Richmond Publ. Co., Slough.

JOHANNSEN, O.A. 1935. *Aquatic Diptera Part II. Orthorrhapha-Brachycera and Cyclorrhapha.* Cornell University Agricultural Experiment Station, memoir **177**, 62 pp + 12 pl.

MCCAFFERTY, W.P. & A.G.B. THOMAS. 1994. Book review: Ward, J.V. 1992. Aquatic insect ecology 1. Biology and habitat. John Wiley & Sons, Inc., New York, XI + 438 pp, ISBN 0-471-55007. *Bulletin of the Entomological Society of Canada*, **26** (1): 26-31.

MATHIS, W.N. & K.D. GHORPADÉ. 1985. Studies of Parydrinae (Diptera: Ephydridae), I. A review of the genus *Brachydeutera* Loew from the Oriental, Australian, and Oceanian regions. *Smithsonian Contributions to Zoology*, n° **406**: 1-25.

MATHIS, W.N. & W.E. STEINER Jr. 1986. An adventive species of *Brachydeutera* Loew in North America (Diptera : Ephydridae). *Journal of the New York entomological Society*, **94** (1): 56-61.

MATILE, L. 1993. *Diptères d'Europe Occidentale*, tome 1. 439 pp. Atlas d'Entomologie, Boubée, Paris.

THOMAS, A., C. BOSCA, A. DAUTA & J-J. TROUBAT. 1997. *Brachydeutera longipes* Hendel, 1913 (Diptera : Ephydridae), the major component of macroneuston in a purification lagoon in French Guiana. North American Benthological Society, 45$^{th}$ Annual Meeting, San Marcos, Texas: communication n° 349. *Bulletin of the North American Benthological Society*, **14** (1): abstract p. 176.

WARD, J.V. 1992. *Aquatic insect ecology 1. Biology and habitat.* John Wiley & Sons, Inc., New York, XI + 438 pp.

WIRTH, W.W. 1964. A revision of the shore flies of the genus *Brachydeutera* Loew (Diptera: Ephydridae). *Annals of the entomological Society of America*, **57**: 3-12.

WIRTH,W.W., W.N. MATHIS & J.R. VOCKEROTH. 1987. Chapter 98: Ephydridae (pp 1027-1047). *In* J.F. McAlpine & coll. (eds): *Manual of Nearctic Diptera*, Volume 2. Research Branch Agriculture Canada, monograph n° **28**.