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The Copepods (Crustacean: Copepod) and Fish (Osteichthyes) That Inhabit in the Fluvial Ecosystems from Sancti Spíritus Province, Cuba

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Abstract

Biological control, as alternative of confrontation of vector organisms, is becoming more necessary every day due to the development of resistance to insecticides. The objective of this investigation consisted in identifying the species of copepods and fishes that inhabit in the fluvial ecosystems of Sancti Spíritus province, with emphasis in the species with best bio regulators qualities about larval populations of culicids. The investigation comprised the period 2000-2011. In the case of copepods, they were reported new records of the genus *Mesocyclops* from Cuba, where the species identified possess good bio regulators qualities; in especial, about the first immature phase or stage of mosquitoes. In relation to fluvial fishes, six samplings were carried out in 90 fluvial ecosystems of eight municipalities from the province, where 15 species of fishes grouped in 12 geneses and six families were identified. High bio regulator capacity of the species *Gambusia punctata* and *Gambusia puncticulata* was demonstrated, which gave evidence of changes in the populations of the provincial current fluvial ictiofauna.

Keywords

Copepods, Biological Control, Fluvial Ecosystems, Sancti Spíritus

Subject Areas: **Aquaculture, Fisheries & Fish Science**

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1. Introduction

In the last decades, mankind faces the emergence and reemergence of various infectious diseases transmitted by vectors, which have been increasing around the world, due to the growing population, the extreme environmental changes, the increase of human immigrations and air travels [1] [2]. Nowadays, these diseases have been appearing in areas where were previously controlled and eliminated [3] [4]. The great epidemics of dengue and malaria occurred in the last years were an example [5]-[7]. Moreover, the epidemics by the chikungunya virus spread by *Aedes albopictus* and *Aedes aegypti* mosquitoes in the isles La Reunion and Mauricius during 2005-2006, with an estimated of 266,000 infected persons and 248 deaths [8] and the one occurred in the summer of 2007 in Italy, where more than 200 cases were diagnosed [9] [10].

Most effective measures against vectors transmitted diseases are, undoubtedly, the control of the vector insect; for that purpose the most common action is the use of insecticides, which is controversial, because it is expensive, it induces the apparition of the resistance and contaminates the environment [11]-[13]. Despite many worldwide efforts, the wader transmitters of dengue and malaria have not been eliminated.

The use of biological methods has become in an alternative option with great potentialities for mosquitoes control; in fact, the use of copepods (small crustaceans) that can be found in almost all the kinds of habitat results in unquestionable importance [14]-[16]. This contrasts with the scarce knowledge about the group, mainly in tropical zones. In Mexico, several states do not have any fauna record of copepods [17] [18]; where the copepods have been greatly studied in the College of the South Frontier (ECOSUR) Chetumal Unit and the Institute of Biology, Autonomy University of Mexico.

The increase of mosquito transmitted diseases compromises every time the scientific community to prioritize the alternative searches of biological control, where the use of larviphagos fish is highlighted. This has been greatly increasing, mainly in tropical countries; where mosquito transmitted diseases constitute a scourge for human health [19]. In these cases, the larviphagos fish are one of the few alternatives of control at their reach and some occasions, the only agent of biological control available [20] [21].

Together with the introduction of aloctonous species, it is now, the warming of the planet and intensification of extreme meteorological disturbance, which has brought changes in the behavior of diseases and transmitters [22]. They are also added: the disproportionate growing of cities, the increase of number of breeding grounds, and the scarce knowledge in ecological material about culicids and methods of confrontation [21].

Because the geographical location of Cuba, the climatological characteristics and archipelago with numerous small islands and open keys, it is not far from the negative consequences of the introduction of exotic species in fluvial ecosystems where inhabit the native fish bio regulators of mosquito larvae, many of them, vectors of diseases, for human and animal health [23].

The investigations carried out about the fluvial ictiofauna in the central part of Cuban archipelago are scarce and even more, the one is related to the use of river fish in the control of larval populations of mosquitoes with entomoepidemiological interest.

The objective of this investigation is to identify the copepods species and fish that inhabit the fluvial ecosystems of Sancti Spíritus province, mainly the ones possessing bio regulators potentialities about larval populations of mosquitoes.

2. Materials and Methods

2.1. Description of the Study Place

Sancti Spíritus province is located in the centern part of Cuba, formed by eight municipalities: Yaguajay, Jatibonico, Taguasco, Cabaiguán, Fomento, Trinidad, Sancti Spíritus and La Sierpe. It is limited to the west of Villa Clara, to the east, with Ciego de Ávila province, to the south with Cienfuegos (**Figure 1**). The surface extension of the province is 673,651 km^2, with a total of 462,758 habitants, for a population density of 68.69 habitants per km^2 and has 194 population settings. The investigation comprised the period 2000-2011.

2.2. About Copepods

Copepods specimens were collected in four municipalities of the province (Cabaiguán, La Sierpe, Sancti Spíritus and Trinidad). To collect the specimens it was used a colander of 14 × 15 × 13 cm with a net of 200 cm, the specimens were moved to the laboratory in plastic recipients with water of the own reservoirs.

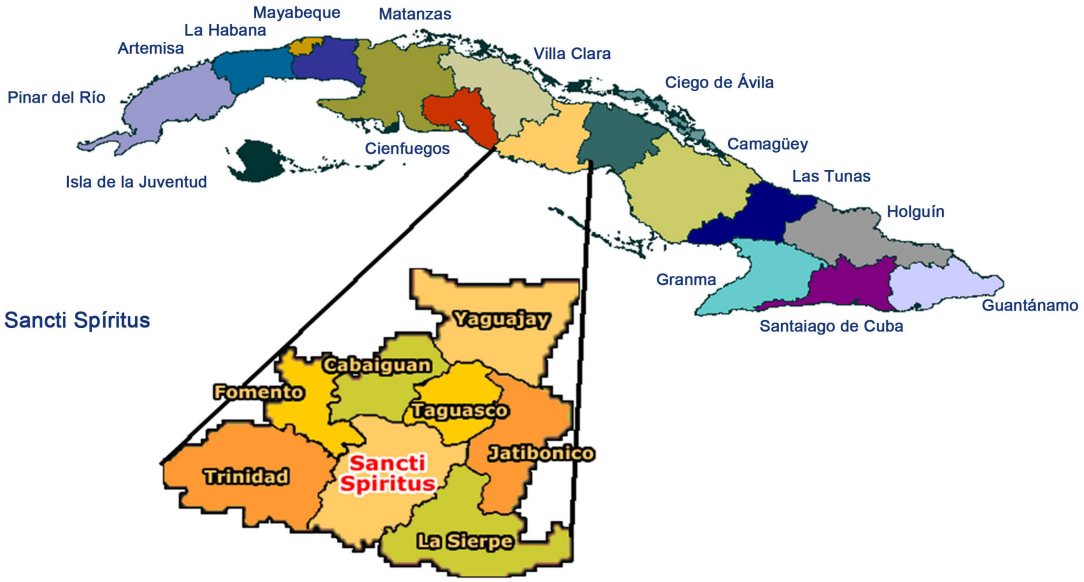

Figure 1. Administrative map of Cuba and Sancti Spíritus province. **Source**: Provincial Meterological Center of Sancti Spíritus.

In the laboratory the copepods were separated using a stereoscopic microscope of dissection Wild M5; the samples were fixed in solution of etilic alcohol to 70% to which was added three or four drops of Koenike liquid (composed by 45% of glycerin, 45% water and 10% of acetic glacial acid), the Koenike liquid is used in conservation and to fix samples to achieve an optima preservation of the material. The samples were sent to Natural History Museum from Virginia in The United States of America, for identification. The specimens were placed in such museum. The study comprised a period of five years (2003 till 2007).

2.3. About Fluvial Fish

The investigation was focused in fluvial ecosystems which constitute places of ovipositor and breeding of larval populations of mosquitoes, as well as habitat of river fish. In total there were sampled 90 reservoirs. There were carried out six samples, two in the year 2000 (the first in March and the second, in June), two in the year 2005 (in March and June) and two in the year 2011 (March and August), thus there were comprised two existing season periods in Cuba (rainy: May to October and less rainy: November to April).

To collect fluvial fish in the reservoirs, it was used a colander of milimetric plastic network (1.5 mm of diameter), with the following dimensions: 70 cm of length × 50 cm of width × 50 cm of depth, with 150 cm of handle. There were carried out three launches with the colander, ranging 2.5 m of distance between launches; always in the places of greatest presence of fish; the samples were placed in plastic recipients of 250 ml, with formol solutions of 2%, counting the quantity of collected specimens there were taken notes of the main characteristics, regarding coloration; we take note copies of freshly caught fish that died and those who were transferred to the laboratory was taken alive, since the key is based on the characteristics of the latter, especially, coloring, it changes the death of the fish [24].

Besides, alive specimens were moved in plastic recipients and nylon bags to the laboratory of the Institute of Tropical Medicine “Pedro Kourí”. To identify the collected fish there were used keys of Alayo (1973), Koldenkova & García (1990) and Jannagblin & Alvariño (1997) [24]-[26]. To determine correctly the species there were distributed the fish samples by sizes, selecting mainly the adult specimens, to have five or six specimens of the same species.

3. Results and Discussion

There were identified four species of copepods in equal quantity of municipalities. Cabaiguán municipality resulted in being the highest number of collected specimens, as well as of the species (two), followed by Sancti Spíritus municipality. The species with the highest quantities of specimens was *M. aspericornis* (**Table 1**).

Table 1. Relation of copepods species collected by species and municipalities.

Identified species	Cabaiguán	La Sierpe	Sancti Spíritus	Trinidad	Total
Mesocyclops aspericornis	35 Females	--	10 Females	--	**45**
Mesocyclops reidae	1 Female	--	2 Females and 1 male	--	**4**
Macrocyclops albidus	--	--	--	4 Females	**4**
Mesocyclops pehpeiensis	--	2 females	--	--	**2**
Total	**36**	**2**	**13**	**4**	**55**

Mesocyclops aspericornis (Daday, 1906). **Sancti Spíritus**, Cabaiguán municipality. Arroyo Lajas, in temporal reservoir (pond). June 24 of 2003. Rigoberto Fimia Duarte. Tested Material: three adult females. Diagnosed by: Janet W. Reid. **Sancti Spíritus**, Sancti Spíritus municipality, pond inside the horse farm "Serafín Sánchez", in temporal reservoir (pond). August 21 of 2004. Rigoberto Fimia Duarte. Tested Material: ten adult females. Diagnosed by: Janet W. Reid.

Mesocyclops reidae Petkovski, 1986. Major synonym: *Mesocyclops ellipticus* of Smith & Fernando 1978 and Collado *et al*. 1984. **Sancti Spíritus**, Cabaiguán municipality. Arroyo Lajas, in a temporal reservoir (pond). June 24 of 2003. Rigoberto Fimia Duarte. Tested Material: a female adult. Diagnosed by: Janet W. Reid. **Sancti Spíritus,** Sancti Spíritus municipality. A pond inside the horse farm of the Institute Pre-Vocational Exact Sciences "Serafín Sánchez", Olivos I. August 21 of 2004. Rigoberto Fimia Duarte. Tested Material: two adult females and a male. Diagnosed by: Janet W. Reid.

Together with this last material collected in the pond inside the horse farm, they were also identified some Cladoceros and Ostracodas (21/08/2004). Afterwards it was carried out another sent to the Natural History Museum, next to this location (Building 31. Apartment 10, Olivos II), but the place of collection was in a plastic tank used to store up water from municipality aqueduct. Collection dates corresponded to October 6 and 18 of 2004, and were diagnosed 32 females of *M. aspericornis.*

Observations: In Sancti Spíritus province there were carried out two samples, the first one has just been detailed, in which there were identified two species, the first one (*M. aspericornis*) constituted a new record for Cuba and the second one (*M. reidae*), for Sancti Spíritus province. Next collection was made on April 16 of 2004, diagnosing in September of 2006; a female and a male, both adults and with copepodite. In that occasion, the collection was made in a lentic meander of the cited stream. Consequently, this constituted the first record of a wild species in Cuba (*M. aspericornis*), although it is supposed that must be found in several places of the Mayor and Minor Antilles. In the case of *M. reidae* was registered previously in Cuba, such as *Mesocyclops ellipticus* by Smith and Fernando (1978), who collected it in a pond from Havana province.

Macrocyclops albidus (Jurine, 1820). **Sancti Spíritus**, Trinidad municipality. Useless washing machine tank with mud and gravel at the bottom. June 2 of 2004. Rigoberto Fimia Duarte. Tested Material: four adult females. Diagnosed by: Janet W. Reid.

Mesocyclops pehpeiensis Hu, 1943. **Sancti Spíritus,** La Sierpe municipality. Pond "The Maloja", almost covered of floating vegetation (*Salvinia auriculata*), temporal reservoir. August 15 of 2005. Rigoberto Fimia Duarte. Tested Material: two adult females. Diagnosed by: Janet W. Reid.

With these samples in Sancti Spíritus municipalities, it is corroborated the existing potential in Cuba since the point of view of micro crustaceans (copepods) fauna to be possibly used in mosquitoes larvae fight, either *Stegomyia aegypti* Linnaeus, 1762, or *Culex quinquefasciatus* Say, 1823 and *Anopheles albimanus* Wiedemann, 1821; which confirms the stated and tested by many investigators [27]-[32].

It is necessary to have knowledge about copepods and more than that, to use adequately only the species that have bio regulator potentialities and not the ones which are intermediate hosts of a great number of parasites of the lymphatic system and of the subcutaneous tissues (group of diseases known by filariosis, caused by nematodes worms), typical example, it is the dracontiasis, where the microfilariae are developed to the point to be ineffective (one or two weeks) inside a copepod of the genus *Cyclops.*

This work evidences the need of keys to identify fluvial copepods, not only from Cuba, but also from Antilles [33]. Therefore, it was increased the list of river copepods species, from 26 to 27, constituting a new record for Cuba the incorporation of this species (*M. aspericornis*), which has proved to have bio regulator qualities

against mosquitoes larvae of first stage, proven and demonstrated fact in various parts of the world [34]-[36], who refer deaths between 70% - 86% using 25 copepods.

In relation to the results about fluvial fish, are shown below. In six samplings carried out in 90 fluvial ecosystems were possible to identify 15 species of fish, gathered in 12 genus and six families (**Table 2**).

From the six identified families, the Poeciliidae was the best represented and distributed when being present in 100% of the municipalities studied (**Table 3**). From the total of identified species, the greatest quantity corresponded to the endemic and naturalized (11), which coincides with the ictiofauna of South America and the Caribbean Isles, and corroborates the theory of Iturralde and MacPhee (1999) [37] in relation to the origin of Cuban flora and fauna, which have been demonstrated by Rodríguez (2001) [38] for South America and Rojas *et al*. (2004) [39] in Perú.

The municipalities where were collected a greater number of fish specimens resulted in Sancti Spíritus, Yaguajay, Cabaiguán and Fomento; that is, municipalities with coastal ecosystems, pre mountainous and mountainous, where undoubtedly, the variety of ecosystems is greater, which gives more possibilities for organisms biodiversity [40] [41]. In the case of the municipalities that took the first two places (Sancti Spíritus and Yaguajay), the number of fluvial ecosystems sampled (29 y 20) was superior to the rest of the municipalities.

There were collected a total of 15,260 of fish specimens, from which 10,068 were females (66, 0%) and 4710 (30, 8%) males and It is necessary to take into account that the exotic species *T. rendalli* and *C. gariepinus* were not determined the sex (482/3, 15% specimens), because the total of collected specimens were alevines and youthful; that is, they were in immature phases of their biological cycle, which makes difficult the sex determination [42] [43].

The number of identified individuals in the 90 ecosystems sampled in different years showed a total of 6348 specimens in the year 2000, equivalent to 41, 5% of the collected total (15,260). In 2005, the number increased to 7561, for 49, 5%, meanwhile in 2011, this number decreased rapidly, to only 1351 specimens, for 8, 8%.

In the case of species by municipalities, resulted in firstly *P. reticulata* (31, 7%), followed by *G. punctata* (27, 4%), then *Girardinus metallicus* (12, 1%), fourthly, *Limia vittata* (10, 7%) and then *G. puncticulata* (7, 2%), the species best represented and distributed. The greatest values of numbers of individuals by species, regarding municipalities, corresponded firstly to Sancti Spíritus (4923/32, 2%), secondly Yaguajay (2824/18, 5%), Cabaiguán (2007/13, 1%) and Fomento (1643/10, 7%). They are confirmed Yaguajay municipalities (12 species), Fomento and Sancti Spíritus (both with 10 species) as well as the greatest riches of species, all this can be appreciated in **Table 4**.

Table 2. Fluvial Ictiofauna of Sancti Spíritus, according to species, condition and family.

Species	Condition	Family
Gambusia punctata (Poey, 1854)	E	Poeciliidae
Gambusia puncticulata (Poey, 1854)	N	Poeciliidae
Girardinus denticulatus (Garman, 1895)	E	Poeciliidae
Girardinus falcatus (Eigenmann, 1903)	E	Poeciliidae
Girardinus metallicus (Poey, 1854)	E	Poeciliidae
Limia vittata (Guichenot, 1853)	E	Poeciliidae
Poecilia reticulata (Peters, 1895)	N	Poeciliidae
Xiphophorus maculatus (Geinther, 1866)	I	Poeciliidae
Cyprinodon variegatus (Poey, 1860)	N	Cyprinodontidae
Cubanichthys cubensis (Eigenmann, 1903)	E	Cyprinodontidae
Cichlasoma tetracanthus (Cuvier y Valenciennes, 1831)	N	Cichlidae
Tilapia rendalli (Boulenger, 1897)	I	Cichlidae
Clarias gariepinus (Burdrell, 1882)	I	Ictaluridae
Dormitator maculatus (Bloch, 1792)	N	Eleotridae
Betta splendens (Regan, 1884)	I	Osphronemidae

Legend. E: Endemic; I: Introduced; N: Naturalized. **Source**: Laboratory of Biological Control of the Vice direction of Parasitology of the Institute of Tropical Medicine "Pedro Kourí" (IPK).

Table 3. Distribution of fluvial fish families by municipalities.

Municipalities	Identified Families						Total
	Poeciliidae	Cyprinodontidae	Cichlidae	Ictaluridae	Eleotridae	Osphronemidae	
Yaguajay	X	X	X	-	-	-	**3**
Jatibonico	X	-	-	-	-	X	**2**
Taguasco	X	-	-	-	-	-	**1**
Cabaiguán	X	-	-	-	-	-	**1**
Fomento	X	-	X	X	-	-	**3**
Trinidad	X	X	-	-	X	-	**3**
S. Spíritus	X	-	X	X	-	X	**4**
La Sierpe	X	-	X	X	-	-	**3**
Total	**8**	**2**	**4**	**3**	**1**	**2**	20

Source: Laboratory of Biological Control of the Vice direction of Parasitology of the Institute of Tropical Medicine "Pedro Kourí" (IPK).

Table 4. Distribution of collected fish specimens by species and municipalities in six samples carried out. 2000, 2005 and 2011.

Fish Species	Municipalities								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Total**
Gambusia punctata	995	205	424	144	721	240	1156	303	4188
Gambusia puncticulata	280	37	0	7	195	86	471	37	1113
Girardinus denticulatus	63	0	0	0	0	0	0	0	63
Girardinus falcatus	117	0	0	1	18	0	0	0	136
Girardinus metallicus	466	0	249	58	197	0	859	22	1851
Limia vittata	527	0	161	18	193	63	551	134	1647
Poecilia reticulata	4	373	628	1769	187	229	1471	189	4850
Xiphophorus maculatus	152	0	0	0	26	0	93	0	271
Cyprinodon variegatus	0	0	0	0	0	380	0	0	380
Cubanichthys cubensis	91	0	0	0	0	0	0	0	91
Cichlasoma tetracanthus	37	0	0	5	28	0	66	19	155
Tilapia rendalli	60	0	5	5	57	0	136	3	266
Clarias gariepinus	32	0	0	0	21	0	118	45	216
Dormitator maculatus	0	0	0	0	0	30	0	0	30
Betta splendens	0	1	0	0	0	0	2	0	3
Total	**2824**	**616**	**1467**	**2007**	**1643**	**1028**	**4923**	**752**	**15,260**

Legend: 1: Yaguajay, 2: Jatibonico, 3: Taguasco, 4: Cabaiguán, 5: Fomento, 6: Trinidad, 7: Sancti Spíritus, 8: La Sierpe.

G. punctata was the species best divided and distributed in Sancti Spíritus reservoirs before the year 2000, followed by naturalized species *P. reticulata* and *G. puncticulata* [44]. In this study, it was *P. reticulata* and *G. punctata* passed to second position, but most notorious and alarming was that *G. puncticulata* took fifth place, after *G. metallicus* and *L. vittata* and this, was one of the species more abundant and best distributed in our

country some years ago [43] [45], this fact was corroborated by the drastic decrease of specimens of such species by samples, of 1040 in four samples of the years 2000 and 2005 went only to 73 in two samples of the year 2011, such decrease is attributed to, regarding the number of specimens and presence in the ecosystems of *G. puncticulata*, to the substancial increase in the levels of contamination of Sancti Spiritus fluvial ecosystems (home activity, agriculture and the industries) and exacerbation of the interspecific competence, mainly, with the exotic species introduced in these fluvial ecosystems, mainly, *T. rendalli* and *C. gariepinus*, which possess a major ecological plasticity and capacity of adaptation than the native species [46] [47].

In the case of exotic species introduced in the breeding grounds where ovipositioned and breed mosquitoes (*B. splendens*, *C. gariepinus*, *T. rendalli* and *X. maculatus*), the third of these was present in six municipalities, meanwhile the second one was collected in four municipalities; *X. maculatus*, in three and only in Jatibonico and Sancti Spíritus municipalities, the species *B. splendens*. Yaguajay, Fomento and Sancti Spíritus municipalities showed a greater number of species, as well as the values of abundance or relative densities regarding to the introduced species (with three of the four collected ones).

References

[1] Arcari, P., Tapper, N. and Pfueller, S. (2007) Regional Variability in Relationships between Climate and Dengue/DHF in Indonesia. *Singapore Journal of Tropical Geography*, **28**, 251-272. http://dx.doi.org/10.1111/j.1467-9493.2007.00300.x

[2] Cepero, R.O. (2012) El cambio climático: Su efecto sobre enfermedades infecciosas. *REDVET*, **13**. http://www.veterinaria.org/revistas/redvet/n050512B.html

[3] Kyle, J.L. and Harris, E. (2008) Global Spread and Persistence of Dengue. Annual Review. *Microbiology*, **62**, 71-92. http://dx.doi.org/10.1111/j.1467-9493.2007.00300.x

[4] WHO (2008) Dengue y dengue hemorrágico. Nota Descriptiva N-117. Revisión de mayo 2008.

[5] Cassab, A., Morales, V. and Mattar, S. (2011) Factores climáticos y casos de dengue en Montería, Colombia. 2003-2008. *Revista de Salud Pública*, **13**, 1-12. http://dx.doi.org/10.1590/S0124-00642011000100010

[6] Maron, G.M., Escobar, G.A., Hidalgo, E.M., Clara, A.W., Minnear, T.D., Martínez, E., *et al.* (2011) Characterization of Dengue Shock in Pediatric Patients in El Salvador. *The Pediatric Infectious Disease Journal*, **30**, 449-450. http://dx.doi.org/10.1097/INF.0b013e318212ab8e

[7] Lugones, B.M. and Ramirez, B.M. (2012) Dengue. *Revista Cubana de Medicina General Integral*, **28**, 1-4.

[8] Reiter, P., Fontenille, D. and Paupy, C. (2006) *Aedes albopictus* as an Epidemic Vector of Chikungunya Virus: Another Emerging Problem? *The Lancet Infectious Diseases*, **6**, 463-464. http://dx.doi.org/10.1016/S1473-3099(06)70531-X

[9] Delatte, H., Dehecq, J.S., Thiria, J., Domerg, C., Paupy, C. and Fontenille, D. (2008) Geographic Distribution and Developmental Sites of *Aedes albopictus* (Diptera: Culicidae) during a Chikungunya Epidemic Event. *Vector-Borne and Zoonotic Diseases*, **8**, 25-34. http://dx.doi.org/10.1089/vbz.2007.0649

[10] Dehecq, J.S., Baville, M., Marqueron, T., Mussard, R. and Filleul, L. (2011) The Remergence of the Chikungunya Virus in Reunion Island on 2010. Evaluation of the Mosquito Control Practices. *Bulletin de la Société de Pathologie Exotique*, **2**, 153-160. http://dx.doi.org/10.1007/s13149-010-0121-5

[11] Collado, C., Defaye, D., Dussart, B.H. and Fernando, C.H. (1984) The Freshwater Copepoda of Costa Rica with Notes on Some Species. *Hydrobiologia*, **119**, 89-99. http://dx.doi.org/10.1007/BF00011948

[12] Schaper, S., Hernández, F.C. and Soto, L. (1998) La lucha contra el dengue: Control biológico de larvas de *Aedes aegypti* empleando *Mesocyclops thermocyclopoides* (Crustacea: Copepoda). *Revista Costarricense Ciencias Médicas*, **19**, 1-6.

[13] Suárez, E.M. and Silva, A. (2002) Extensión del ámbito geográfico de dos copépodos heliclópinos (Copepoda: Cyclopoida: Halicyclopinae) en el sureste de México. *Serie Zoologia*, **73**, 113-115.

[14] Hernández, F.C. and Schaper, S. (2000) *Mesocyclops thermocyclopoides* (Copepoda: Cyclopoida): A Scanning Electron Microscopy Study. *Revista Latinoamericana de Microbiología*, **42**, 53-56.

[15] Lardeux, F., Riviere, F., Sechan, Y. and Loncke, S. (2002) Control of the *Aedes* Vectors of the Dengue Viruses and *Wuchereria bancrofti*: The French Polynesian Experience. *Annals of Tropical Medicine and Parasitology*, **96**, 105-116. http://dx.doi.org/10.1179/000349802125002455

[16] Kosiyachinda, P., Bhumiratana, A. and Kittayapong, P. (2003) Enhancement of the Efficacy of a Combination of *Mesocyclops aspericornis* and *Bacillus thuringiensis* var. Israelensis by Community-Based Products in Controlling *Aedes aegypti* Larvae in Thailand. *American Journal of Tropical Medicine and Hygiene*, **69**, 206-212.

[17] Hernández, F. and Schaper, S. (1999) La lucha contra el dengue: Control biológico de las larvas de *Aedes aegypti* empleando *Mesocyclops thermocyclopoides* (Crustacea). *Revista costarricense de ciencias médicas*, **20**, 17-21.

[18] Salas, I., Escalante, N., Dante, H. and Ponce, G. (2005) Utilización de copépodos en el control de *Aedes aegypti*. Simposio Control Biológico del mosquito *Aedes aegypti*. Edición especial No. 6. México. http://www.respyn.uanl.mx/especiales/2005/ee-06-2005/documentos/06.html

[19] Ghosh, S.K., Chakaravarthy, P., Panch, S., Krishnappa, P., Tiwari, S., Ojha, V.P., *et al.* (2011) Comparative Efficacy of Two Poeciliid Fish in Indoor Cement Tanks against Chikungunya Vector *Aedes aegypti* in Villages in Karnataka, Índia. *BMC Public Health*, **11**, 599. http://dx.doi.org/10.1186/1471-2458-11-599

[20] Manna, B., Aditya, G. and Banerjee, S. (2011) Habitat Heterogeneity and Prey Selection of *Aplocheilus panchax*: An Indigenous Larvivorous Fish. *Journal of Vector Borne Diseases*, **45**, 144-149.

[21] Aditya, G., Pal, S., Saha, N. and Saha, G. (2012) Efficacy of Indigenous Larvivorous Fishes against *Culex quinquefasciatus* in the Presence of Alternative Prey: Implications for Biological Control. *Journal of Vector Borne Diseases*, **49**, 217-225.

[22] Gore, A. (2007) An Inconvenient Truth [videocinta]. Paramount Classics and Participant Productions, EUA.

[23] Cádiz, T.L. (2005) Especies en peligro de extinción. *Revista Mar y Pesca*, **349**, 30-31.

[24] Koldenkova, L. and García, I. (1990) Clave pictórica para las principales especies de peces larvívoros de Cuba. Instituto de Medicina Tropical «Pedro Kourí», Poligráfico «Pablo de la Torriente Brau», La Habana, 1-56.

[25] Alayo, P.D. (1973) Lista de los peces fluviátiles de Cuba. *Rev Torreia*, 14-24.

[26] Jannagblin, J. and Alvariño, L. (1997) Peces larvívoros con potencial para el control biológico de estadios inmaduros de zancudos del Perú. *Revista Peruana Entomología*, **40**, 9-19.

[27] Riviere, F. and Thirel, R. (1981) La prédation du copépode *Mesocylops leuckarti pilosa* (Crustacea) sur les larves de *Aedes* (*stegomyia*) *aegypti*, *Ae.* (*St.*) *polynesiensis* [*Diptera*: *Culicidae*]: Essais préliminaires d' utilisation comme agent de lutte biologique. *Entomophaga*, **26**, 427-439. http://dx.doi.org/10.1007/BF02374717

[28] Suárez, M.F., Ayala, D., Nelson, M.J. and Reid, J.W. (1984) Hallazgo de *Mesocyclops aspericornis* (Daday) (Copepoda: Cyclopoida) depredador de larva de *Aedes aegypti* en Anapoima-Colombia. *Biomédica*, **4**, 74-76. http://dx.doi.org/10.7705/biomedica.v4i2.1885

[29] Kay, B.H., Cabral, C.P., Sleigh, A.C., Brown, M.D., Ribeiro, Z.M. and Vasconcelos, A.W. (1992) Laboratory Evaluation of Brazilian *Mesocylops* (Copepoda: Cyclopoida) for Mosquito Control. *Journal of Medical Entomology*, **29**, 599-602. http://dx.doi.org/10.1093/jmedent/29.4.599

[30] Marten, G.G. and Thompson, G. (1997) Copepod Production and Application for Mosquito Control. New Orleans Mosquito Control Board, New Orleans, 1-42.

[31] Reid, J.W. and Suárez, E.M. (1999) A New, Neotropical Species of *Acanthocyclops* (Copepoda: Cyclopoida: Cyclopoidae). *Beaufortia*, **49**, 37-44.

[32] de Faria, A.E., Hayashi, C. and Soares, C.M. (2001) Predacao de larvas de pacu (*Piaractus mesopotamicus*, Holmberg) por copépodos ciclopóides (*Mesocyclops longisetus*, Thiébaud) em diferentes densidades e ambientes e com diferentes contrastes visuais. *Acta Scientiarum*, **23**, 497-502.

[33] Smith, K.E. and Fernando, C.H. (1978) The Freshwater Calanoid and Cyclopoid Copepod Crustacea of Cuba. *Canadian Journal of Zoology*, **56**, 2015-2023. http://dx.doi.org/10.1139/z78-271

[34] Nam, V.S., Yen, N.T., Holynska, M., Reid, J.W. and Kay, B.H. (2000) National Progress in Dengue Vector Control in Vietnam: Survey for *Mesocyclops* (Copepoda), *Micronecta* (Corixidae), and Fish as Biological Control Agents. *American Journal of Tropical Medicine and Hygiene*, **62**, 5-10.

[35] Kay, B.H. and Nam, V.S. (2005) New Strategy against *Aedes aegypti* in Vietnam. *Lancet*, **365**, 613-617. http://dx.doi.org/10.1016/S0140-6736(05)17913-6

[36] Marten, G.G. and Reid, J.W. (2007) Cyclopoid Copepods. In: Floore, T.E., Ed., *Biorational Control of Mosquitoes*, *American Mosquito Control Association Bulletin*, No. 7, EUA, 65-92.

[37] Iturralde, V.M. and MacPhee, R.D.E. (1999) Paleogeography of the Caribbean Region: Implications for Cenozoic Biogeography. Bulletin of the American Museum of Natural History, No. 238, New York.

[38] Rodríguez, J.P. (2001) La Amenaza de las especies exóticas para la conservación de la biodiversidad suramericana. Revista del Instituto Nacional de Investigaciones Científicas (INIC) de Caracas, Venezuela, **26**, 8-17.

[39] Rojas, E.P., Gamboa, M.B., Villalobos, S.P. and Cruzado, F.V. (2004) Eficacia del control de larvas de vectores de la malaria con peces larvívoros nativos en San Martín, Perú. *Revista Peruana de Medicina Experimental y Salud Publica*, **21**, 44-50.

[40] Acha, P.N. and Szyfres, B. (2003) Zoonosis y enfermedades transmisibles comunes al hombre y los animales. 3rd

Edition, Editorial Científico-Técnica, La Habana, 284-292.

[41] González, B.R. (2006) Culícidos de Cuba. 1st Edition, Editorial Científico-Técnica, La Habana.

[42] Bernardo, J.M., Ilhén, M., Matono, P. and Costa, A.M. (2003) Interannual Variation of Fish Assemblage Structure in a Mediterranean River: Implications of Streamflow on the Dominance of Native or Exotic Species. *River Research and Applications*, **19**, 521-532. http://dx.doi.org/10.1002/rra.726

[43] Contreras, N.H., Villarejo, I.D., Fernández, A.S., Duarte, R.F. and Palacios, N.O. (2006) Determinación de la ictiofauna que participa en el control de culícidos en sistemas acuáticos del municipio Guamá, Santiago de Cuba. *Revista Cubana de Medicina Tropical*, **58**, 32-36.

[44] Morejón, M.P. (1992) Eficacia del *Bacillus sphaericus* Neide, 1904 Cepa 2362 y peces larvívoros para el control de larvas de mosquitos (Diptera: Culicidae). Tesis de maestría, Instituto de Medicina Tropical "Pedro Kourí", La Habana.

[45] García, I.A. and González, R.B. (1986) Principales especies de la familia *Poecilidae* y su efectividad en las condiciones de Cuba. *Revista Cubana Medicina Tropical*, **38**, 197-202. http://bvs.sld.cu/revistas/gme/pub/vol.6.(1)_04/p4.html

[46] Ishikawa, T. and Tachihara, K. (2010) Life History of the Nonnative Convict Cichlid *Amatitlania nigrofasciata* in the Haebaru Reservoir on Okinawa-Jima Island, Japan. *Environmental Biology of Fishes*, **88**, 283-292. http://dx.doi.org/10.1007/s10641-010-9641-x

[47] Argota, P.G., González, Y., Argota, H., Fimia, R. and Iannacone, J. (2012) Desarrollo y bioacumulación de metales pesados en *Gambusia punctata* (Poeciliidae) ante los efectos de la contaminación acuática. *REDVET. Revista electrónica de Veterinaria*, **13**.