

FIRST RECORDS OF THE FAIRY SHRIMP *STREPTOCEPHALUS MOOREI*  
(BRANCHIOPODA: ANOSTRACA) FROM THE UNITED STATES

Alejandro M. Maeda-Martínez, D. Christopher Rogers, and Richard D. Worthington

(AMMM, correspondence) Centro de Investigaciones Biológicas del Noroeste, S. C., Apartado postal 128,  
La Paz, Baja California Sur, 23000, México (almaeda04@cibnor.mx);  
(DCR) EcoAnalysts, Inc., 166 Buckeye Street, Woodland, California 95695, U.S.A.  
(RDW) University of Texas, El Paso, P.O. Box 13331, El Paso, Texas 79913, U.S.A.

ABSTRACT

We report the first two records of the fairy shrimp *Streptocephalus moorei* from the United States, previously known only from its type locality in southeastern Chihuahua, México. An updated morphological diagnosis and habitat data are provided. *Streptocephalus moorei*, previously considered as a critically endangered species under the IUCN red list criteria, is now assessed as an endangered species on the basis of the following criteria: area of occupancy estimated to be less than 500 km<sup>2</sup>, known to exist at no more than five locations, and extreme fluctuations in the number of mature individuals. Appropriate measures should be taken to protect this species, such as additional survey efforts and monitoring of extant populations.

Almost 25% of the anostracan species are known only from their type localities (Belk and Brtek, 1995, 1997). In the genus *Streptocephalus* Baird, 1852, of the 13 species recognized from the New World, *S. antillensis* Mattox, 1950, *S. kargesi* Spicer, 1985, *S. moorei* Belk, 1973, and *S. potosinensis* Maeda-Martínez *et al.*, 1995a, have been reported only from a single location (Maeda-Martínez *et al.*, 1995a), and *S. guzmani* Maeda-Martínez *et al.*, 1995a, *S. mattoxi* Maeda-Martínez *et al.*, 1995a, and *S. wootoni* Eng, Belk, and Eriksen, 1990, have been considered geographically restricted species (Eng *et al.*, 1990; Brown *et al.*, 1993; Maeda-Martínez *et al.*, 1995a). The last three species and *S. moorei* were listed in the 1996 IUCN red list of threatened animals. *Streptocephalus wootoni* is the only streptocephalid included in the endangered species list of the United States by the U.S. Fish and Wildlife Service and thus is the only member of the family receiving legal protection (Federal Register, 1993).

During studies on two ephemeral pools in southern New Mexico, U.S.A., in 1995, 1999, and 2000, two of us (DCR and RDW) collected specimens of *Streptocephalus moorei*, a species previously known only from the state of Chihuahua, México. These new records represent a considerable extension of the distribution range of the species. The objective of this paper is to formally report this species from the United States and to update the morphological diagnosis, habitat data, and conservation status of the species.

MATERIALS AND METHODS

The material examined is deposited in the collections of Centro de Investigaciones Biológicas del Noroeste, S. C. (CIB), La Paz, Baja California Sur, México, and the private collections of D. Christopher Rogers (DCR), and Denton Belk (DB) (currently deposited at the National Museum of Natural History, Smithsonian Institution, Washington, D. C., U.S.A.).

Standard length values (measured from the anterior margin of the head to the posterior margin of the telson between the cercopods) are given for the specimens examined. Measurements were made using a vernier caliper under a stereoscopic microscope. Terminology used in the morphological diagnosis follows Maeda-Martínez *et al.* (1995a, b). The extinction risk

assessment for this species was made using the IUCN red list categories and criteria (2001).

RESULTS

*Streptocephalus moorei* Belk, 1973

Fig. 1

*Streptocephalus moorei* Belk, 1973.—Brtek, 1974; Belk, 1975; Spicer, 1985; Maeda-Martínez, 1991; Maeda-Martínez *et al.*, 1995a, b, 2002.

*Type Material*.—Holotype and paratypes at National Museum of Natural History, U.S.A. (USNM 141454, 141455), paratypes at Muzeum v Bonjniciach, Bojnice, Czechoslovakia (VII/a-2510), and at Loyola University Museum, New Orleans, Louisiana, U.S.A. (LU-1341). The type material was collected on 30 August 1971 by J. J. Landye (Belk, 1973).

*Type Locality*.—Federal highway 45, 10 miles N of Jiménez, Chihuahua, México, 27°20'N, 104°55'W (Belk, 1973).

*New Localities*.—(1) Stock tank on south side of road, dug into playa, 13.5 road miles (21.7 road km) E of Columbus (T29S, R6W, ctr. Sec.12), Luna County, New Mexico, U.S.A., 31°47.98'N, 107°24.55'W (GPS). (2) Stock tank, dug into Cedar Lake Playa, Armenderas Ranch, Sierra County, New Mexico, U.S.A., 33°13'41.29"N, 107°01'33.50"W (GPS).

*Material Examined*.—From type locality: Paratypes DB 062, 2 males, 14.4, 15.0 mm, 2 females, 12.0, 12.2 mm, collected 30 August 1971 by J. J. Landye. From Columbus: DCR-183, 6 males, 5.4–7.2 mm, collected 12 October 1995 by R. Worthington; DCR-192, 1 female, 8.2 mm, collected 26 September 1999 by R. Worthington; and DCR-194, 24 males, 16.0–18.6 mm, CIB-450, 3 males, 16.7–18.6 mm, collected 13 October 1999 by R. Worthington. From Armenderas Ranch: DCR-236, 8 males, 16.7–18.6 mm, collected 17 September 2000 by D. C. Rogers and B. Lang. All the material from the new localities was identified by D. C. Rogers.

*Diagnosis*.—Male (abbreviations refer to labels in Fig. 1): peduncle (pd) of distal outgrowth of long type, without pulvinus; first geniculation of peduncle bearing medial, ventrally directed, large digitiform protuberance (dp); inner surface of distal portion of peduncle with 4 to 10 small conical protuberances, variable in size; lateral surface of distal part of peduncle, near base of hand bearing 6 to 12

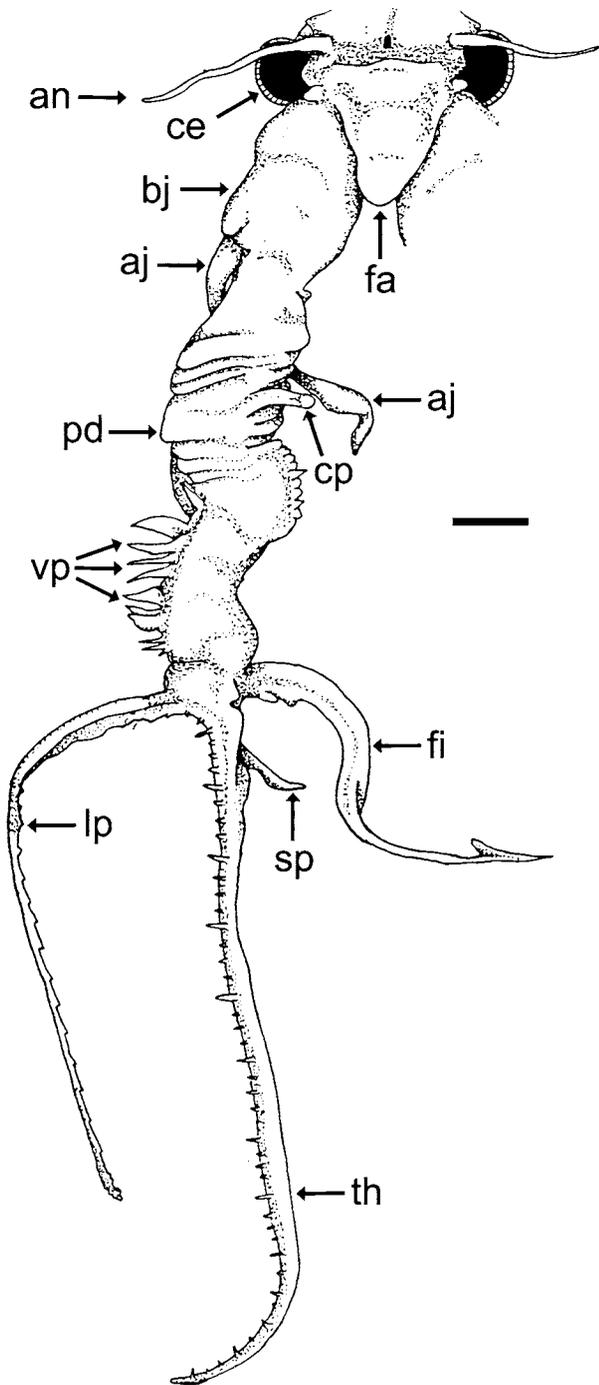


Fig. 1. Anterior view of head and right antenna of male of *Streptocephalus moorei* Belk, 1973 (specimen from Columbus, Luna County, New Mexico, U.S.A.). aj, apical joint; an, antennule; bj, basal joint; ce, compound eye; cp, conical protuberance; fa, frontal appendage; fi, finger; lp, curved process from base of thumb; pd, peduncle; sp, spur; th, thumb; and vp, lateral vermiform protuberances of peduncle. Scale bar = 1.0 mm.

vermiform protuberances (vp); dorsolateral surface of base of thumb (th) with long, anterodorsally directed, subacuminate process that curves ventrally apically; spur (sp) broad at base, narrow at middle; spur bearing subapical rounded dorsal protuberance; apex of spur subacuminate, anteroventrally directed; lateral lamella with acute angle between

distal part of thumb and spur; inner lamella medioventrally produced, forming cavity; thumb elongate, proximal two-thirds slightly curved upward, last third strongly curved; apex of thumb acuminate; dorsal margin with series of unequal peg-like spines; finger (fi) bigeniculate, inner dorsal side of proximal part, with single, anteromedially directed, hump-like tooth; apex of finger acuminate, with subapical, ventrolaterally directed, digitiform structure; distal segment of second antenna with apex fleshy; frontal appendage short; genitalia without linguiform outgrowths; cercopods separate, setose along inner and lateral borders; anus terminal.

Female. Ovaries biramous, variably extending from thoracic segments 9–11 to abdominal segments 6–8; cysts spherical, ornamented by ribs forming polygonal areas.

*Remarks.*—On the diagnosis of the species based on the type material, Maeda-Martínez *et al.* (1995a) wrote “frontal appendage short, distal part with a pair of conical protuberances, in ventrolateral position.” After a reexamination of males of the type material, the frontal appendage appears short and finishes slightly bilobed. The frontal appendage in males of the new material is relatively longer and is subacuminate (Fig. 1). Here the ventrolateral conical protuberances are on the middle part and not on the distal part. This difference may be a size-dependant variation, given that the males collected from New Mexico are larger than those of the type material. An additional feature of the male *S. moorei* not mentioned before is the fleshy consistency of the apex of the distal segment of the second antenna, which is typically chitinous in most *Streptocephalus* species.

*Differential Diagnosis.*—*Streptocephalus moorei* exhibits the most complex distal antennal outgrowth of all American species, and bears a number of similarities with *S. antillensis*. The unique features of *S. moorei* are (1) the large digitiform protuberance on the inner side at the first geniculation of the peduncle, (2) the series of 8 to 12 vermiform protuberances on the lateral side of the distal part of the peduncle, and (3) the long, curved process on the dorsolateral side of the base of the thumb (Maeda-Martínez *et al.*, 1995a) (Fig. 1).

*Species Group.*—*Streptocephalus moorei* is considered as part of the *torvicornis* group, *mackini* subgroup. The *torvicornis* group is distributed in Africa, the Arabian peninsula, Europe, and North America; the *mackini* subgroup is distributed only in North America. The diagnostic characteristics of the *mackini* subgroup are male with frontal appendage simple and short; peduncle of distal outgrowth long, without pulvinus; spur of thumb well developed; genitalia without linguiform outgrowths; cercopods setose; female with biramous ovaries (Maeda-Martínez *et al.*, 1995b).

*Distribution and Ecology.*—Type locality (Fig. 2): The ecology of *Streptocephalus moorei* at the type locality is poorly known. Specimens of the species have been collected only once at this location. In August 1971, *S. moorei* was collected along with *S. mackini* Moore, 1966, *Thamnocephalus platyurus* Packard, 1879, *Triops* sp., *Eocyclus digueti* (Richard, 1895), and *Leptestheria compleximanus* (Packard, 1877) (Belk, 1973). The type locality is in the

Bolsón de Mapimí of the Chihuahuan desert and is close to the eastern margin of Río Florido, which is part of the Río Conchos basin. The site is at an altitude of about 1200 meters above sea level. According to INEGI (1988), the climate is dry semihot (BWh, Köppen's system), with an annual mean precipitation of about 300 mm. The surrounding vegetation is the typically xerophyte, with *Prosopis* sp. and *Larrea tridentata* as the relevant species. In September 1985 and 2002, one of us (AMMM) visited the type locality. On both dates, there were ponds along Highway 45 for about 3 km to the north and 3 km to the south of the type locality. No *S. moorei* specimen was found. The ponds contained other large branchiopods, including *S. mackini*, *T. platyurus*, *Triops* sp., and *Eulimnadia texana* Packard, 1871. In 1985, one of the ponds had a surface area of 5 × 2 m, 8-cm deep, with sandy bottom; the water temperature was 36°C (air 30°C), TDS (total dissolved solids) 0.32 g L<sup>-1</sup>, and Secchi disc transparency 4.0 cm.

**New localities:** In the site close to Columbus, Luna County (Fig. 2), there is a stock tank excavated in a playa on the south side of Highway 9, on Bureau of Land Management property. The playa lies west of the West Potrillo Mountains in the Chihuahua desert, at an elevation of 1206 meters above sea level. The climate is dry semihot (BWh, Köppen's system), rainfall averages 9.2-in per year with a little more than half falling during the summer monsoon season of July to September (Gabin and Lesperance, 1977). The stock tank portion of the playa is approximately 2000 m<sup>2</sup>, and may fill to more than a meter depth. Both the playa and the adjacent alkali flats are dominated by alkali saccaton *Sporobolus airoides* (Torr.). The soil substrate is in the Honde-Mimbres complex, which is characterized by having a high clay fraction, high alkalinity (pH 8.5–9.0), low permeability, moderate water capacity, and enough salinity to affect tilth (Neher and Buchanan, 1980). In late Pleistocene, the site was within the pluvial Lake Palomas (Hawley, 1993). The tank was visited in October 1995, September and October 1999, and September 2000. The water was turbid, with visibility rarely more than a few centimeters caused by suspended silt. *Streptocephalus dorotheae* Mackin, 1942, *S. mackini*, and *Eulimnadia texana* were also present in the tank.

In the site of Cedar Lake Playa, Armenderas Ranch, Sierra County (Fig. 2), there is a stock tank excavated in a playa on the east side of county road CR-A13. The playa lies in the Jornada del Muerto Valley in the Chihuahuan desert just east of the Fray Cristobal Mountains at an elevation of 1200 m. The climate is dry semihot (BWh, Köppen's system), rainfall averages 9.2-in per year with a little more than half falling during the summer monsoon season of July to September (Gabin and Lesperance, 1977). The stock tank portion of the playa is approximately 2500 m<sup>2</sup>, and may fill to more than a meter depth. Soil data were not available. In the late Pleistocene, the site was within the pluvial Lake Trinity (Hawley, 1993). The tank was visited in October 2000. The water was turbid, with visibility rarely more than a few centimeters caused by suspended silt. *Streptocephalus dorotheae* and *Eulimnadia texana* were also present in the tank. Cedar Lake and the stock tank dug into it are actively used as a water source by pronghorn antelope,

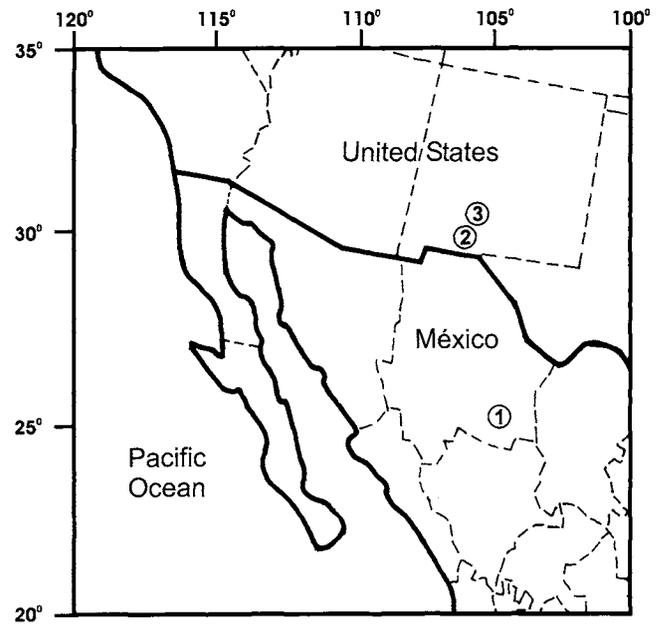


Fig. 2. Geographical distribution of *Streptocephalus moorei* Belk, 1973. 1. 10 miles N of Jiménez, Chihuahua, México (type locality); 2. 13.5 road miles (21.7 road km) E of Columbus, Luna County, New Mexico, U.S.A.; 3. Cedar Lake Playa, Armenderas Ranch, Sierra County, New Mexico, U.S.A.

American bison, mule deer, naturalized Arabian oryx, and other wildlife species. During the site visit, a flock of blue winged teal were startled from the tank.

**Conservation Status.**—Before this study, *Streptocephalus moorei* was considered endemic to the southeastern region of the state of Chihuahua, México, and was included as a critically endangered species (CR) in the IUCN Red List (IUCN, 1996). The new sites (Columbus and Armenderas) are situated about 600–750 km north of the type locality. Given these new records, we assess *S. moorei* as an endangered species (EN) on the basis of the following criteria: area of occupancy estimated to be less than 500 km<sup>2</sup>, known to exist at no more than five locations, and extreme fluctuations in number of mature individuals.

#### DISCUSSION

The species inventory and the geographical distribution of large branchiopods of the northern Chihuahuan desert have received little attention. There are still large gaps in the large branchiopod distribution records across the region, including the northern parts of the Mexican states of Chihuahua and Coahuila (Obregón-Barboza *et al.*, 2002).

The occurrence of active adult fairy shrimp at a given time is hard to predict because this depends on multiple factors: the inundation of the water body and the successful hatching of the dormant cysts. Cyst hatching depends on, among other factors, a particular range of water temperature (Belk, 1977), and thus may result in seasonally restricted occurrence or in a succession of species. Therefore, as proposed by Obregón-Barboza *et al.* (2002), to obtain a reasonably complete inventory, a seasonal sampling program of repeated visits to representative temporary

ponds is required. Although *S. moorei* was collected in New Mexico in 1995, 1999, and 2000, no specimen of the species has been collected from the type locality since its original collection in 1971. However, during two visits in the area in 1985 and 2002, other large branchiopod species were found living in the ponds of the area.

With the information obtained from the new populations, *Streptocephalus moorei* can now be considered as an endangered species (EN). Currently, no protection exists for the species. Its occurrence at the type locality is threatened by the extension of the Federal Highway No. 45, which is altering the habitat. Habitat destruction has been classified as the greatest threat to biodiversity (Wilcove *et al.*, 1998), and it certainly is to the crustaceans of ephemeral pools (Belk, 1998; Fugate, 1998). Therefore, appropriate measures should be taken to protect the species. Meanwhile, repeated seasonal sampling is urgently needed, not only to establish a large branchiopod inventory but also for an accurate evaluation of the conservation status of the species.

#### ACKNOWLEDGEMENTS

The authors thank Tim Messick for scanning DCR's drawing of *S. moorei*. Field studies at the type locality in Chihuahua, México, during 1985 and 2002 were supported by the Consejo Nacional de Ciencia y Tecnología, México (projects PCECBNA-021463, and 35137-V). The authors also thank Brian Lang of New Mexico Department of Game and Fish for assistance collecting throughout New Mexico, and the Armenderas Ranch for access to their properties.

#### LITERATURE CITED

- Belk, D. 1973. *Streptocephalus moorei* n. sp., a new fairy shrimp (Anostraca) from Mexico.—*Transactions of the American Microscopical Society* 92: 507–512.
- . 1975. Key to the Anostraca (fairy shrimp) of North America.—*The Southwestern Naturalist* 20: 91–103.
- . 1977. Zoogeography of the Arizona fairy shrimps (Crustacea: Anostraca).—*Journal of the Arizona Academy of Science* 12: 70–78.
- . 1998. Global status and trends in ephemeral pool invertebrate conservation: implications for Californian fairy shrimp. Pp. 147–150 in C. W. Witham, E. Bauder, D. Belk, W. Ferren, and R. Ornduff, eds. *Ecology, Conservation, and Management of Vernal Pool Ecosystems*. California Native Plant Society, Sacramento, California.
- , and J. Brtek. 1995. Checklist of the Anostraca.—*Hydrobiologia* 298: 315–353.
- , and ———. 1997. Supplement to 'Checklist of the Anostraca'.—*Hydrobiologia* 359: 243–245.
- Brown, J. W., H. A. Wier, and D. Belk. 1993. New records of fairy shrimps (Crustacea: Anostraca) from Baja California, Mexico.—*Southwestern Naturalist* 38: 389–390.
- Brtek, J. 1974. Zwei *Streptocephalus*-Arten aus Afrika und einige notizen zur gattung *Streptocephalus*.—*Annotationes Zoologicae et Botanicae*, Bratislava 96: 1–9.
- Eng, L. L., D. Belk, and C. H. Eriksen. 1990. Californian Anostraca: distribution, habitat, and status.—*Journal of Crustacean Biology* 10: 247–277.
- Federal Register. 1993. Federal Register 3 August 1993. Determination of endangered status for three vernal pool plants and the Riverside fairy shrimp.—*Federal Register* 58: 41384–41392.
- Fugate, M. 1998. *Branchinecta* of North America: population structure and its implications for conservation practice. Pp. 140–146 in C. W. Witham, E. Bauder, D. Belk, W. Ferren and R. Ornduff, eds. *Ecology, Conservation, and Management of Vernal Pool Ecosystems*. California Native Plant Society, Sacramento, California.
- Hawley, J. W. 1993. Geomorphic Setting and Late Quaternary History of Pluvial-Lake Basins in the Southern New Mexico Region. New Mexico Bureau of Mines and Mineral Resources. Open-File Report 391.
- INEGI. 1988. Atlas Nacional del Medio Físico. Instituto Nacional de Estadística, Geografía e Informática, México. 223 pp.
- IUCN. 1996. 1996 IUCN Red List of Threatened Animals. IUCN, Gland, Switzerland. 10 + 368 pp.
- IUCN. 2001. IUCN Red List Categories and Criteria: Version 3.1. IUCN Species Survival Commission. IUCN, Gland, Switzerland and Cambridge, United Kingdom. 2 + 30 pp.
- Gabin, V. L., and L. E. Lesperance. 1977. New Mexico Climatological Data: Precipitation, Temperature, Evaporation, and Wind, Monthly and Annual Means, 1850–1975. W. K. Summers and Associates.
- Maeda-Martínez, A. M. 1991. Distribution of species of Anostraca, Notostraca, Spinicaudata, and Laevicaudata in Mexico.—*Hydrobiologia* 212: 209–219.
- Maeda-Martínez, A. M., D. Belk, H. Obregón-Barboza, and H. J. Dumont. 1995a. Diagnosis and phylogeny of the New World Streptocephalidae (Branchiopoda: Anostraca).—*Hydrobiologia* 298: 15–44.
- , ———, ———, and ———. 1995b. A contribution to the systematics of the Streptocephalidae (Branchiopoda: Anostraca).—*Hydrobiologia* 298: 203–232.
- , H. Obregón-Barboza, H. García-Velazco, and M. A. Prieto-Salazar. 2002. Branchiopoda: Anostraca. Pp. 305–322 in J. Llorente-Bousquets and J. J. Morrone, eds. *Biodiversidad, Taxonomía y Biogeografía de Artrópodos de México*. Volumen III. Universidad Nacional Autónoma de México, México.
- Neher, R. E., and W. A. Buchanan. 1980. Soil survey of Luna County, New Mexico. U. S. Department of Agriculture, Soil Conservation Service.
- Obregón-Barboza, H., A. M. Maeda-Martínez, H. García-Velazco, and H. J. Dumont. 2002. *Branchinecta oterosanvicentei* n. sp. (Branchiopoda: Anostraca), a new fairy shrimp from the Chihuahua desert, with a proposal for the conservation of the Branchinectidae of México.—*Hydrobiologia* 467: 45–56.
- Spicer, G. S. 1985. A new state record of *Streptocephalus texanus* Packard (Anostraca) from Mexico.—*The Southwestern Naturalist* 27: 244–245.
- Wilcove, D. S., D. Rothstein, J. Dubow, A. Phillips, and E. Losos. 1998. Quantifying threats to imperiled species in the United States.—*Bioscience* 48: 607–616.

RECEIVED: 2 December 2004.

ACCEPTED: 10 May 2005.