Artículos Científicos

División Académica de Ciencias Biológicas
Using cornstarch in microparticulate diets for larvicultured tropical gar (Atractosteus tropicus)
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**ABSTRACT**

Aquaculture in Mexico has been developed by the cultivation of commercial species. In Tabasco, the cultivation of native species is mainly limited by the lack of nutrition studies to support its crop profitability. Among these species is the tropical gar (Atractosteus tropicus), which has great potential for cultivation. However, the nutritional value of carbohydrates in diets for this species which contribute to improved growth and survival, have not been evaluated. Thus, in the present investigation, isoprotein and isolipid diets have been designed based on the substitution of cellulose by corn starch (D1: 0 % starch–15 % cellulose, D2: 7.5 % starch–7.5 % cellulose and D3: 15 % starch–0 % cellulose) and compared with a commercial trout diet (45 % protein and 16 % lipids). A total of 1800 larvae (0.008 ± 0.002 g and 10.5 ± LT 0.126 mm) were used, distributed in a recirculation system in order to evaluate growth and survival for 30 days. The results show higher growth and survival of 97 % of larvae fed the D3 diet, while cannibalism in the species was mitigated. Major digestive enzyme activities occurred (acid protease, alkaline protease, trypsin, chymotrypsin, leucine aminopeptidase, carboxypeptidase A, lipase, α-glucosidase and amylase) for larvae fed D3. It is concluded that the contribution of corn starch (15 %) replacing cellulose in the diet improves growth and survival of this species.

Keywords: Amylase; Carbohydrates; Glucosidase; Lipase; Proteases; Tropical gar
**Assessment of phenotypic diversity and agronomic contrast in American accessions of *Jatropha curcas L.***

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**ABSTRACT**

This study was conducted to determine the genetic variation and relationships between American accessions of *Jatropha curcas* from different origins. The accessions from El Salvador showed the lowest plant proportions, while two of the Mexican accessions (MCT10 and MCE06) showed the highest values in oil yield. The principal component analysis explained 75.99% of the total variation in three components. Repeatability analysis showed a low effect of the environment on the characters associated with oil yield (R = 0.99), 100-seed weight (R = 0.98) and seed volume (R = 0.97), indicating a high level of diversity among accessions and the feasibility of finding desirable characters in each collection, while offering useful information for the selection of parental plants for use in crop improvement programs.

Keywords: Agro-morphological descriptors; Diversity; *Jatropha curcas*; Phenotypic expression; Yield traits
Distribution of *Pterygoplichthys* spp. (*Siluriformes: Loricariidae*) in the low basin of the Grijalva-Usumacinta rivers. [Distribución de *Pterygoplichthys* spp. (*Siluriformes: Loricariidae*) en la Cuenca baja de los ríos Grijalva-Usumacinta]

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**ABSTRACT**

The records of 3,967 specimens of *Pterygoplichthys* spp. in 6 associations of aquatic macrophytes in 6 areas of wetlands confirm its dispersion in the lower basin of the Grijalva-Usumacinta rivers. The loricariids in submerged rooted vegetation need attention, since they represent another risk for these associations of aquatic macrophytes, which shelter high biodiversity.

**Keywords:** Aquatic macrophytes; Invasive species; Wetlands
A new species of *Phlebopus* (*Boletales, basidiomycota*) from Mexico

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ABSTRACT

A new species, *Phlebopus mexicanus*, is described from southern tropical rainforests of Mexico based on morphological and molecular characters. Several features distinguish this species from others of *Phlebopus* including the medium to small basidiomata with olivaceous brown tomentose pileus that becomes finely areolate cracked with age, the dark yellow brown pruina covering most of the stipe, the pale yellow flesh of pileus and stipe that slowly turns blue when exposed, and the lack of *hymenial cystidia*. Phylogenetic analyses using nLSU sequences support the recognition of this new morphological species in the Sclerodermatineae. Our analyses also suggest that *P. portentosus* and *P. marginatus* are not conspecific and relationships of Old World taxa of *Phlebopus* need further scrutiny. A key to all known New World taxa is provided.

Keywords: Boletes; Identification key; Phylogenetics; Sclerodermatineae
Trichoderma diversity in the cocoa agroecosystem in the state of Tabasco, Mexico

[Diversidad de Trichoderma en el agroecosistema cacao del estado de Tabasco, México]

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ABSTRACT

Cocoa plantations of Tabasco are similar to rainforests. This agro-ecosystem contributes to preserve the biodiversity. In Tabasco, diversity studies in the cacao agro-ecosystem are related to the vegetation, mammals, birds, insects and spiders. The fungal diversity has not been studied. The aim of this study was to characterize the diversity of Trichoderma/Hypocrea from the cocoa rhizosphere in cocoa production areas of Tabasco. To this end, 96 strains of Hypocrea/Trichoderma were obtained and identified by morphology and ITS sequences. Trichoderma asperellum, T. brevitectum, T. harzianum/H. lixii, T. koningiopsis/H. koningiopsis, T. longibrachiatum/H. sagamiensis, T. pleuroticola, T. reesei/H. jecorina, T. spirale y T. virens/H. virens, were the identified species. The richness (D_Mg) and abundance (H') indexes were 1.75 y 1.69, respectively. The Pielou uniformity index (J) was 0.77. The highest diversity of Trichoderma/Hypocrea was detected in the Chontalpa subregion. T. harzianum/H. lixii was the most abundant. All the species are first report for the cocoa agroecosystem of Tabasco. Trichoderma asperellum, T. brevitectum, T. koningiopsis/H. koningiopsis, T. pleuroticola, T. reesei/H. jecorina y T. spirale, are new reports for the state. Trichoderma pleuroticola is new record for Mexico.

Keywords: Biodiversity; Cocoa rhizosphere; Micromycetes
ABSTRACT

This study aimed to understand the similarity and diversity of Scolytinae and Platypodinae associated with mangroves in the state of Tabasco, Mexico. During 2012, insects were collected using traps with ethyl alcohol and ultraviolet light. A total of 1,226 specimens were collected and identified, belonging to 25 species and 13 genera; 22 species from 11 genera belonged to Scolytinae and three species from two genera belonged to Platypodinae. The species Coccotrypes rhizophorae, Micracisella opacithorax, and Microcorthylus minimus represent new records for Tabasco. The highest species diversity (H') was obtained in Sánchez Magallanes (SM), with 1.31, and the lowest in San Pedro (SP) with 1.16, without significant differences. The similarity index (Is) showed that SM-SP share the greatest number of species; something similar was observed in alcohol traps as compared with light traps. The species Xyleborus volvulus and Euplatypus parallelus recorded the highest abundance, equivalent to 75% of total, with 651 and 276 individuals, respectively. The use of ethyl alcohol traps allowed the collection of a larger number of species. This study provided knowledge about the composition of Scolytinae and Platypodinae in mangroves in the state of Tabasco; however, more studies are required to achieve a comprehensive knowledge of the population dynamics of these species, particularly of those that could cause damage.

Keywords: Insects. Mangrove. Borers. Tropical.
**Remote monitoring of defoliation by the beech leaf-mining weevil *Rhynchaenus fagi* in northern Spain.**

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**ABSTRACT**

Beech (*Fagus sylvatica L.*) forests are among the most widespread and emblematic deciduous forests in Europe, frequently serving as refuge for several endangered species. Populations of the beech leaf-miner weevil *Rhynchaenus fagi*, a common specific defoliator, usually remain at endemic levels for long periods, but outbreaks occasionally occur under favorable conditions, causing extensive defoliation and forest decline. Monitoring defoliation is highly relevant to integrated beech management, particularly in the beech forests of northern Spain, located in the southernmost range of the Cantabrian Mountains. Monitoring and mapping damage using multispectral satellite remote sensing may be a suitable, cost-effective option in these rugged areas. One hundred eleven defoliation field records from 17 inventory plots over an 8-year period were spectrally related to ten Landsat vegetation indices. A sigmoidal mixed-effects model as a function of vegetation index change for predicting *R. fagi* defoliation in beech stands was developed based on a recently proposed general Landsat model. The Moisture Stress Index (MSI, Band-5/Band-4) was the best fitted model. The DMSI defoliation model yielded 4.0% RMSE and 3.1% MAE defoliation estimated errors and a significant accuracy of 0.685 R² (p < 0.0001) or 0.632 Nagelkerke’s R². Model was applied to map the spatial–temporal pattern of *R. fagi* defoliation on beech stands, and a trend of defoliation oscillation was observed in the area during the 8 year study. Remote sensing-based model represents a cost-effective tool for health monitoring in large, difficult to access, forested mountain areas, such as those studied. Forest management programs, as those aimed to habitat conservation of southern Cantabrian beech forests, will greatly benefit from remote mapping and the assessment of stand vulnerability to insect damage and other disturbances in current climate warming scenarios.

Keywords: Landsat images; Mixed-effects model; Spectral vegetation indices
Development of digestive tract and enzyme activities during the early ontogeny of the tropical gar *Atractosteus tropicus*.

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**ABSTRACT**

Changes in digestive enzyme activity and histology were studied in *Atractosteus tropicus* embryos, larvae and juvenile periods. Alkaline protease, chymotrypsin, carboxypeptidase A, lipase and α-amylase were detected in all periods and gradually increased until reaching the maximum peak in juveniles; meanwhile, acid protease was first detected at 5 days after hatching (dah) when first feeding started and trypsin and leucine aminopeptidase activities were detected from 19 dah, their values being increased gradually until reaching a maximum value at 31 dah. Acid and alkaline phosphatase activities increased from yolk-sac absorption (3 dah) until day 31 after hatching. Zymogram for acid protease showed two bands in active forms (0.4 and 0.5 Rfs) from day 5 after hatching and a third protease form (0.3 Rf) that appears at 31 dah. Two active forms (26.3 and 24.9 kDa) were detected using SDS-PAGE alkaline proteases zymogram at 5 dah, and an additional active form (44.1 kDa) was detected at 7 dah. Regarding the histological development of the digestive system, the exocrine pancreas containing zymogen granules was already visible at 3 dah, whereas at 5 dah first gastric glands were already detected in the stomach. Between 7 and 9 dah, the digestive tract of *A. tropicus* resembled that of a juvenile specimen with a well-developed and short oesophagus, stomach divided into a glandular and non-glandular (pyloric) stomach, folded intestine with pyloric caeca and a well-developed spiral valve (posterior intestine). Considering this, larvae of *A. tropicus* are capable of digesting several foods from yolk absorption (3 dah), maximizing its activities at 15 dah, age at which the organisms maximize its capability to absorb nutrients from diets provided.

Keywords: *Atractosteus tropicus*, Ontogeny, Proteases
Unique evolutionary trajectories in repeated adaptation to hydrogen sulphide-toxic habitats of a neotropical fish (*Poecilia mexicana*).

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**ABSTRACT**

Replicated ecological gradients are prime systems to study processes of molecular evolution underlying ecological divergence. Here, we investigated the repeated adaptation of the neotropical fish *Poecilia mexicana* to habitats containing toxic hydrogen sulphide (H2S) and compared two population pairs of sulphide-adapted and ancestral fish by sequencing population pools of >200 individuals (Pool-Seq). We inferred the evolutionary processes shaping divergence and tested the hypothesis of increase of parallelism from SNPs to molecular pathways. Coalescence analyses showed that the divergence occurred in the face of substantial bidirectional gene flow. Population divergence involved many short, widely dispersed regions across the genome. Analyses of allele frequency spectra suggest that differentiation at most loci was driven by divergent selection, followed by a selection-mediated reduction of gene flow. Reconstructing allelic state changes suggested that selection acted mainly upon de novo mutations in the sulphide-adapted populations. Using a corrected Jaccard index to quantify parallel evolution, we found a negligible proportion of statistically significant parallel evolution of J\textsubscript{corr} = 0.0032 at the level of SNPs, divergent genome regions (J\textsubscript{corr} = 0.0061) and genes therein (J\textsubscript{corr} = 0.0091). At the level of metabolic pathways, the overlap was J\textsubscript{corr} = 0.2545, indicating increasing parallelism with increasing level of biological integration. The majority of pathways contained positively selected genes in both sulphide populations. Hence, adaptation to sulphidic habitats necessitated adjustments throughout the genome. The largely unique evolutionary trajectories may be explained by a high proportion of de novo mutations driving the divergence. Our findings favour Gould’s view that evolution is often the unrepeatable result of stochastic events with highly contingent effects.

Keywords: Adaptation, ecological genetics, evolutionary theory, fish, molecular evolution, parallel evolution
Mechanisms underlying adaptation to life in hydrogen sulfide rich environments.

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**ABSTRACT**

Hydrogen sulfide (H\textsubscript{2}S) is a potent toxicant interfering with oxidative phosphorylation in mitochondria and creating extreme environmental conditions in aquatic ecosystems. The mechanistic basis of adaptation to perpetual exposure to H\textsubscript{2}S remains poorly understood. We investigated evolutionarily independent lineages of livebearing fishes that have colonized and adapted to springs rich in H\textsubscript{2}S and compared their genome-wide gene expression patterns to closely related lineages from adjacent, nonsulfidic streams. Significant differences in gene expression were uncovered between all sulfidic and nonsulfidic population pairs. Variation in the number of differentially expressed genes among population pairs corresponded to differences in divergence times and rates of gene flow, which is consistent with neutral drift driving a substantial portion of gene expression variation among populations. Accordingly, there was little evidence for convergent evolution shaping large-scale gene expression patterns among independent sulfide spring populations. Nonetheless, we identified a small number of genes that was consistently differentially expressed in the same direction in all sulfidic and nonsulfidic population pairs. Functional annotation of shared differentially expressed genes indicated upregulation of genes associated with enzymatic H\textsubscript{2}S detoxification and transport of oxidized sulfur species, oxidative phosphorylation, energy metabolism, and pathways involved in responses to oxidative stress. Overall, our results suggest that modification of processes associated with H\textsubscript{2}S detoxification and toxicity likely complement each other to mediate elevated H\textsubscript{2}S tolerance in sulfide spring fishes. Our analyses allow for the development of novel hypotheses about biochemical and physiological mechanisms of adaptation to extreme environments.

Keywords: Ecological physiology, evolution, extreme environments, gene expression, H\textsubscript{2}S, Poecilia mexicana (Poeciliidae), RNA-sequencing
Using replicated evolution in extremophile fish to understand diversification in elemental composition and nutrient excretion.

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ABSTRACT

1. Ecological sources of selection are key drivers of evolutionary change in populations. Information on the ecological relevance of such evolutionary shifts is comparatively sparse and has received renewed interest. The framework of ecological stoichiometry is useful to investigate the reciprocal effects between ecology and evolution, because data on somatic stoichiometry of ancestral and descendant populations can be used to predict ecological functions, such as nutrient recycling, using mass balance-based models.

2. Here, we investigated whether divergent populations of livebearing fishes (genus Poecilia) have diverged in elemental composition. We tested whether adaptation to local environmental conditions is manifested in changes of somatic stoichiometry by measuring carbon (C), nitrogen (N), phosphorus (P) and sulphur (S) contents of wild-caught individuals inhabiting sulphidic (extreme) and non-sulphidic (benign) habitats. We also attempted to isolate the sources (i.e. genetic, environmental and their interaction) of intraspecific variation in stoichiometry. Finally, we tested whether shifts in somatic stoichiometry impinge on the rates at which key nutrients (N and P) are excreted.

3. We found significant differentiation in somatic stoichiometry between fish from the two different habitat types in two of three river drainages, with fish from sulphidic habitats having lower C but higher P and S contents. Even though there was evidence for temporal variation and plasticity in elemental composition, differences between sulphidic and non-sulphidic populations in P and S contents were maintained in laboratory populations over multiple generations. Finally, some sulphidic and non-sulphidic population pairs differed in the rates of N and P excretions, although excretion rates were not related to somatic stoichiometry.

4. Together, these results show that the elemental composition of organisms appears to have the characteristics typically observed in the evolution of biochemical, physiological and morphological traits. Studying taxa that have undergone replicated evolution illuminate some of the evolutionary mechanisms that drive variation in somatic elemental composition. Applying stoichiometric principles to such variation, as we have performed here, is a useful, yet underutilised approach to understand the ecological relevance of evolutionary change.

Keywords: Ecological stoichiometry, hydrogen sulphide springs, intraspecific variation, \textit{Poecilia mexicana} (Poeciliidae), sulphur.
Reduction of energetic demands through modification of body size and routine metabolic rates in extremophile fish.

Courtney N. Passow\textsuperscript{a}, Ryan Greenway\textsuperscript{a}, Punidan D. Jeyasingh\textsuperscript{a}, Michael Tobler\textsuperscript{a} and Lenin Arias-Rodríguez.

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\end{itemize}

\textbf{ABSTRACT}

Variation in energy availability or maintenance costs in extreme environments can exert selection for efficient energy use, and reductions in organismal energy demand can be achieved in two ways: reducing body mass or metabolic suppression. Whether long-term exposure to extreme environmental conditions drives adaptive shifts in body mass or metabolic rates remains an open question. We studied body size variation and variation in routine metabolic rates in locally adapted populations of extremophile fish (\textit{Poecilia mexicana}) living in toxic, hydrogen sulfide–rich springs and caves. We quantified size distributions and routine metabolic rates in wild-caught individuals from four habitat types. Compared with ancestral populations in nonsulfidic surface habitats, extremophile populations were characterized by significant reductions in body size. Despite elevated metabolic rates in cave fish, the body size reduction precipitated in significantly reduced energy demands in all extremophile populations. Laboratory experiments on common garden–raised fish indicated that elevated routine metabolic rates in cave fish likely have a genetic basis. The results of this study indicate that adaptation to extreme environments directly impacts energy metabolism, with fish living in cave and sulfide spring environments expending less energy overall during routine metabolism.

Keywords: adaptation; cave environments; energy consumption; extreme environments; hydrogen sulfide springs; \textit{Poecilia mexicana}; resource availability
Convergent changes in the trophic ecology of extremophile fish along replicated environmental gradients.

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ABSTRACT

1. Divergent selection along environmental gradients connecting locally restricted extreme habitats and adjacent benign habitats can shape convergent evolution of traits involved in coping with physiochemical stressors and can drive speciation. At the same time, the presence of such stressors alters aspects of the biotic environment, including resource availability and competitive regimes. However, it remains unclear whether and how the ecology of populations occurring in both extreme and benign environments varies in a predictable fashion.

2. We investigated the trophic ecology of live-bearing fishes of the genus \textit{Poecilia} that have independently colonised multiple springs containing toxic hydrogen sulphide in southern Mexico. Sulphide spring fish are adapted to the unique environmental conditions and are reproductively isolated from ancestral populations in adjacent non-sulphidic habitats. We used gut content analyses to test whether colonisation of extreme habitats was accompanied by shifts of trophic resource use and expansions of trophic niche width. Furthermore, we tested whether dietary shifts were reflected in trophic morphology by comparing intestinal tract lengths among populations using both wild-caught and common garden-raised individuals.

3. Gut content analyses revealed that fish inhabiting toxic springs expanded their trophic niche width and changed their dietary resource use from detritus and algae to sulphide bacteria and invertebrates. This dietary shift was paralleled by changes in intestinal tract morphology, whereby sulphide spring fish had shorter intestines than fish from adjacent non-sulphidic habitats. Analysis of common garden-raised fish indicated that morphological differences between sulphidic and non-sulphidic populations are at least in part due to genetic differentiation. Both patterns of trophic resource use and differentiation in trophic morphology were consistent across replicated pairs of sulphidic and non-sulphidic populations, although the magnitude of differentiation varied among river drainages.

4. Our results suggest that colonisation of and adaptation to sulphide springs in southern Mexico was paralleled by convergent changes in trophic ecology. This highlights the complexity of environmental gradients and the necessity of considering multiple sources of selection when studying the evolution of complex phenotypes.

Keywords: dietary niche, ecological diversification, extreme environment, hydrogen sulphide springs, \textit{Poecilia} (\textit{Poeciliidae}).
Brain size variation in extremophile fish: Local adaptation versus phenotypic plasticity.


ABSTRACT
The brain is a plastic organ, and so intraspecific studies that compare results obtained from wild individuals with those from common-garden experiments are crucial for studies aiming to understand brain evolution. We compared volumes of brain regions between reproductively isolated populations of a neotropical fish, Poecilia mexicana, that has locally adapted to perpetual darkness (Cueva Luna Azufre), toxic hydrogen sulphide in a surface stream (El Azufre) or a combination of both stressors (Cueva del Azufre). Wild fish showed habitat-dependent differences: enlarged telencephalic lobes and reduced optic tecta were found in fish living in darkness and sulphidic waters, in darkness without hydrogen sulphide or exposed to light and sulphide; fish from the sulphidic cave additionally showed enlarged cerebella. Comparison with common-garden reared fish detected a general decrease in brain size throughout populations in the lab, and little of the brain size divergence between lab-reared ecotypes that was seen in wild-caught fish. The pronounced differences in brain region volumes between ecotypes in the wild might be interpreted within the framework of mosaic evolution; however, the outcomes of common-garden experiments indicate a high amount of phenotypic plasticity. Our study thus highlights the importance of combining the investigation of brain size in wild populations with common-garden experiments for answering questions of brain evolution.

Keywords: hydrogen sulphide; ecological selection; troglomorphism; cave fish; evolutionary neurobiology; local adaptation.
<table>
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<th>Historical floods in Tabasco and Chiapas during sixteenth–twentieth centuries.</th>
<th>División Académica de Ciencias Biológicas, Universidad Juárez Autónoma de Tabasco.</th>
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**ABSTRACT**

It is presented a chronology of historical floods during sixteenth–twentieth centuries in the Mexican states of Tabasco and Chiapas. There were 41 historical flooding events during 1528–1948, 16 of them were catastrophic flooding and 25 were extraordinary ones. There were periods of historical floods between 1651–1652, 1676–1677, 1679–1680, 1888–1889, 1927–1929, 1931–1933 and 1940–1944. During the instrumental period (1949–1999) there were only four extraordinary flood events in the Usumacinta River. Most of flood periods coincided with the warm phase of the Atlantic Multidecadal Oscillation (AMO). The flood period of 1940–1944 was as long as the most recent one (2007–2011). Wavelet analysis found flood periodicities of 2.5, 52 and 83 years, but only the last one was statistical significant and their occurrence was in phase with the AMO. Logistic regression showed that AMO index was the most correlated index with flood events. In fact, the odds ratio showed that floods were 1.90 times more likely to occur when AMO index was positive. This regression model predicted correctly 64.70 % of flood occurrences during twentieth century using its flood information only as validation data.

**Keywords:** AMO; Historical floods; Tabasco Chiapas
The complete mitochondrial DNA of the tropical 
gar (*Atractosteus tropicus*).

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Centro de Investigaciones Biológicas del 
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Nacional,

**ABSTRACT**

The mitogenome of the tropical gar, *Atractosteus tropicus*, (GeneBank accession number KJ531198) 
has a total length of 16,280 bp, and the arrangement consist of 13 protein-coding genes, 2 ribosomal 
RNA (rRNA) genes and 22 transfer RNA similar to other Lepisosteidae family mitogenomes.

Keywords: *Atractosteus tropicus*; mitochondrial genome; pejelagarto; tropical gar
ABSTRACT

Concentrations of seven metals (As, Cd, Cr, Cu, Pb, Ni, and Zn) were analyzed in 33 bone tissue samples of Antillean manatees (Trichechus manatus manatus) found dead in lagoons and rivers of Tabasco and Campeche in the Gulf of Mexico and Chetumal Bay in the Caribbean region. The concentrations of Cr, Cu, Pb, and Zn were significantly different between regions, with greater levels found in the Gulf of Mexico group than in the Mexican Caribbean group (p < 0.05). Pb concentrations differed significantly between adults and calves. No differences were observed between sexes. Metal concentrations detected in the manatee bones were higher than most of those reported for bones in other marine mammals around the world. Future studies are necessary to establish whether the metal concentrations represent a risk to the health of the species.

Keywords: Antillean manatee; Aquatic pollution; Manatee metals; Wildlife pollution
Evaluation of free flow and subsurface wetlands in wastewater pollutant removal using different vegetation macrophyte species

Silván, R.S.\textsuperscript{a}, Ocaña, G.L.\textsuperscript{b}, Margulis, R.G.B.\textsuperscript{c}, Barajas, J.R.H.\textsuperscript{d}, Cerino, M.J.R.\textsuperscript{e}

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ABSTRACT
The discharge of wastewater containing high loads of turbidity, color, total suspended solids (TSS), total nitrogen (TN), total phosphorus (TP), chemical oxygen demand (COD) and biochemical oxygen demand (BOD\textsubscript{5}), damages aquatic and terrestrial ecosystems. Such pollutant discharges should be brought to low levels to mitigate ecosystem contamination. The present study evaluated artificial free flow wetlands that were implemented to operate with Typha domingensis (southern cattail) and Eichhornia crassipes (water hyacinth), as well as subsurface flow wetlands using Paspalum paniculatum (hyacinth) and Cyperus articulatus L (jointed flat sedge), to remove contaminants from wastewater. Lagoons without vegetation and gravel lagoons were built with gravel as controls. A nonparametric Kruskal-Wallis analysis was carried out to assess significant differences between the four treatments and the controls. The highest wastewater pollutants removal efficiency was that of the free flow wetland using T. domingensis (removal efficiencies of turbidity, color, COD, BOD\textsubscript{5}, NT, PT and SST of 97.1, 83.4, 97.8, 97.5, 97.2, 91.1 and 97.7\% respectively), followed by the subsurface flow wetland using P. paniculatum, with removals of 94.8, 71.5, 94.7, 94.8, 92.7, 52.2 and 93.0\% respectively. Free flow wetlands using E. crassipes and subsurface flow wetland with C. articulatus had the lowest contaminant removal efficiencies. The hydraulic retention times were of 5.5 and 7.5 days.
ABSTRACT
Cocoa plantations of Tabasco are similar to rainforests. This agro-ecosystem contributes to preserve the biodiversity. In Tabasco, diversity studies in the cacao agro-ecosystem are related to the vegetation, mammals, birds, insects and spiders. The fungal diversity has not been studied. The aim of this study was to characterize the diversity of Trichoderma/Hypocrea from the cocoa rhizosphere in cocoa production areas of Tabasco. To this end, 96 strains of Hypocrea/Trichoderma were obtained and identified by morphology and ITS sequences. Trichoderma asperellum, T. brevicompactum, T. harzianum/H. liiiii, T. koningiopsis/H. koningiopsis, T. longibrachiatum/H. sagamiensis, T. pleuroticola, T. reesei/H. jecorina, T. spirale y T. virens/H. virens, were the identified species. The richness (DMg) and abundance (H') indexes were 1.75 y 1.69, respectively. The Pielou uniformity index (J) was 0.77. The highest diversity of Trichoderma/Hypocrea was detected in the Chontalpa subregion. T. harzianum/H. liiiii was the most abundant. All the species are first report for the cocoa agroecosystem of Tabasco. Trichoderma asperellum, T. brevicompactum, T. koningiopsis/H. koningiopsis, T. pleuroticola, T. reesei/H. jecorina y T. spirale, are new reports for the state. Trichoderma pleuroticola is new record for Mexico.

Keywords: Biodiversity; Micromycetes; Cocoa rhizosphere
La selva inundable de canacoite en Tabasco, México, una comunidad vegetal amenazada

Emerson Maldonado Sánchez¹, Susana Ochoa Gaona², Rodimiro Ramos Reyes³, Ma. de los Ángeles Guadarrama Olivera¹, Noel González Valdivia⁴ y Bernardus H.J. de Jong²

ABSTRACT

Se analizó la estructura, composición y diversidad arbórea de los dos rodales más importantes de selva mediana perennifolia de Bravaisia integerrima (SMPC) de Tabasco, México: el de la Reserva Ecológica Yu-Balcah (YCAH) con una superficie de 271 ha y el del Parque Estatal La Chontalpa (PECH) con 191 ha. En cada uno se levantaron 10 parcelas de muestreo de 1000 m², cubriendo un área total de 2 ha. Se identificó y registró a las plantas arbóreas, diferenciando brinzales, plantas juveniles y adultos. Se aplicaron diversos índices para analizar el esfuerzo de muestreo, la diversidad de especies, la abundancia proporcional, la dominancia y la equidad. El análisis estructural se basó en el valor de importancia. La riqueza total fue 76 especies, pertenecientes a 64 géneros y 31 familias botánicas, de las que la mejor representada fue Leguminosae con 15 especies. El área basal de YCAH y PECH fue de 37.2 y 29.5 m²ha⁻¹, respectivamente. Bravaisia integerrima fue el árbol con mayor valor de importancia en los dos rodales con un Índice correspondiente de 277. Ambos fragmentos 75 tienen un valor del índice de Shannon de 2.0. El sitio con mejor condición ecológica fue YCAH. Se identificaron seis especies catalogadas en la NOM-059-SEMARNAT-2010. La SMPC presenta una cobertura actual en Tabasco de 490 ha. Los resultados sugieren que su estructura y composición se han visto afectados por la actividad antrópica en la región. Para garantizar la conservación de los remanentes de SMPC en el estado, es importante revisar y actualizar su situación legal y sus planes de manejo, así como generar alternativas sociales y productivas en las poblaciones cercanas. Para lograrlo se requiere de la participación de actores gubernamentales, académicos, organizaciones no gubernamentales, particulares y sociedad en conjunto.

Keywords: Bosques de Bravaisia, diversidad florística, reserve ecológica
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<td><strong>Chemical Composition of the leaves rodeo dicolor Medical plant Distribute in Central america and Mexico using X-Ray diffraction spectroscopy</strong></td>
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<td>Lopez-Martinez Sugey¹, Ignacio Lopez Y celis², Victor Hugo Lara Corona², Jose Rodolfo Velazquez-Martinez³</td>
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<td><strong>ABSTRACT</strong></td>
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<td>X-ray diffraction is a direct, fast and non-destructive method to detect and analyze powder samples. In this work, we used powder X-ray diffraction to unequivocally characterize samples of the tissue of dry leaves of Rhoeo discolor. This species is considered a medicinal plant; it is known in Tabasco as &quot;purple maguey&quot;. The peaks of X-ray diffraction were calculated based on the structures of experimental diffractograms, providing a practical way of identifying relevant compounds in the analyzed material. Using the method of micro-proton-induced X-ray emission to determine the composition of the leaves of this plant used in traditional medicine, we detected three molecules not previously reported for this species. These molecules can be used as an anticaking or detergent agent, or in water purification. These compounds may be of commercial importance and could give Rhoeo discolor an added value.</td>
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<td><strong>Keywords:</strong> Purple agave, medicinal plant, spectroscopy, X-ray diffraction, <em>Rhoeo discolor</em></td>
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## ABSTRACT

Concentrations of seven metals (As, Cd, Cr, Cu, Pb, Ni, and Zn) were analyzed in 33 bone tissue samples of Antillean manatees (*Trichechus manatus manatus*) found dead in lagoons and rivers of Tabasco and Campeche in the Gulf of Mexico and Chetumal Bay in the Caribbean region. The concentrations of Cr, Cu, Pb, and Zn were significantly different between regions, with greater levels found in the Gulf of Mexico group than in the Mexican Caribbean group (p<0.05). Pb concentrations differed significantly between adults and calves. No differences were observed between sexes. Metal concentrations detected in the manatee bones were higher than most of those reported for bones in other marine mammals around the world. Future studies are necessary to establish whether the metal concentrations represent a risk to the health of the species.

Keywords: Metals, Aquatic pollution, Wildlife pollution
ABSTRACT

Purpose: To identify occupational risks and practices in the four aerial fumigation facilities in the Sierra banana growing region and to evaluate environmental impacts from Mancozeb use.

Methods: To identify occupational health risks, practices in the four aerial fumigation facilities in the Sierra banana growing region were documented, and semi-structured interviews were conducted with installation managers. To evaluate environmental impact, samples of water and soil were collected and analysed in an acute toxicity bioassay with Vibrio fischeri, using uncontaminated soil and water to establish background levels.

Results: In the two largest and best-equipped facilities, serious risks to workers’ health were encountered from inadequate use of protective equipment by workers. Furthermore, excessive use of pesticide, lack of re-use of unused product, poor facility design and poor use of wash-water were observed, resulting in maximum toxicity of > 5 times background in discharged water. Parallel soil samples were > 20 times more toxic than background, being most toxic at > 0.5 km from the discharge point.

Conclusion: Areas of opportunity to improve worker health and the environment include proper and consistent use of protective equipment, re-use of unused product, wastewater reduction and appropriate wastewater treatment.

Keywords: Black Sigatoka, Ethylene, Thiourea
### Seasonal differences in the feeding habits of the Antillean manatee population (*Trichechus manatus manatus*) in the fluvial-lagoon systems of Tabasco, Mexico

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### ABSTRACT

There are few studies on the availability of food, diet and habitat selection of the Antillean manatee in fresh water, as is the case for manatees that inhabit lagoons and rivers in Tabasco, Mexico. On flood plains, the manatee’s diet is related to flood pulse, the wet phase provide greater access to and diversity of food resources during the rainy season compared to the dry phase. The aim of this study was to evaluate the feeding of the manatee in fluvial-lagoon systems in Tabasco (FLS) during the rainy and dry season, by means of stable isotope analysis of C and N, particularly for the isolate population of Laguna de las Ilusiones (LI).

Samples were collected from plants C3 and C4 and from manatee skin during rainy and dry seasons and the values of $\delta^{13}$C and $\delta^{15}$N were determined. In manatees that inhabit the FLS, there were no significant differences in $\delta^{13}$C or $\delta^{15}$N between seasons. In LI the difference in $\delta^{13}$C was recorded (ANOVA: F1,17=6.75, P=0.018), but not for $\delta^{15}$N. In all the sites, the C3 and C4 plants presented differences in $\delta^{13}$C (p<0.05). In the FLS the C3 plants were more prevalent in the diet than the C4 plants, although there is a noticeable difference in water level and accessibility to plants during the dry season. The percentage of C4 plants in the diet of the LI manatees during the rainy period was 67.8%, whereas during the dry period it was 49.5%. The results indicate that there was no $\delta^{15}$N enrichment as evidence of fasting during the dry season. The changes in $\delta^{13}$C in LI indicate a change in the plants consumed between seasons, which is also evident in the C3/C4 ratio.

Keywords: feeding, stable isotope analysis, Tabasco
Eco-Friendly Spectrophotometric Method as Alternative for Carbon Disulfide-Free Determination of Ethylenethiourea in Surface Water.

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ABSTRACT

The development of rapid, efficient, low-cost and waste-free techniques for the determination of carbamate pesticides and their carcinogenic degradation products is an important research goal especially in developing regions. In this study, a novel procedure for an environmentally friendly analytical method is introduced which does not require the use of carbon disulfide solvent or expensive chromatographic equipment. Using only deionized water as a solvent, the determination of the analyte was accomplished from absorption maximum with a UV spectrophotometer. The method was validated for linearity in the range of 0.01-18 mg/l \((R^2=0.999)\) with a detection limit of 0.06 mg/l, a quantification limit of 0.1 mg/l and a recovery of 106.4%.

There was excellent correlation between expected and observed concentrations \((R^2=0.999)\) and no significant difference was found using different equipment brands or analysts \((p<0.05)\). This method achieves the objective of quantification in recommended permissible limits \((1 \text{ mg/l})\) showing excellent validation in important variables such as linearity, precision and recovery. In addition, it is economical, fast, non-destructive, does not require costly equipment and avoids the use (and disposal) of very toxic and explosive solvent.

Keywords: Dithiocarbamate, ethylenethiourea, spectrophotometry
ABSTRACT

The use of soil health indicators linked to microbial activities, such as key enzymes and respirometric profiles, helps assess the natural attenuation potential of soils contaminated with hydrocarbons. In this study, the intrinsic physicochemical characteristics, biological activity and biodegradation potential were recorded for two soils with different contamination histories (>5 years and <1 months). The enzymatic activity (lipase and dehydrogenase) as well as microbiological and mineralisation profiles were measured in contaminated soil samples. Soil suspensions were tested as microbial inocula in biodegradation potential assays using contaminated perlite as an inert support. The basal respiratory rate of the recently contaminated soil was 15–38 mg C-CO₂kg⁻¹h⁻¹, while the weathered soil presented a greater basal mineralisation capacity of 55–70 mg C-CO₂ kg⁻¹ h⁻¹. The basal levels of lipase and dehydrogenase were significantly greater than those recorded in non-contaminated soils (551±21 μg pNP g⁻¹).

Regarding the biodegradation potential assessment, the lipase (1000–3000 μg pNP g⁻¹ of perlite) and dehydrogenase (~3000 μg INF g⁻¹ of perlite) activities in the inoculum of the recently contaminated soil were greater than those recorded in the inoculum of the weathered soil. This was correlated with a high mineralization rate (~30 mg C-CO₂ kg⁻¹ h⁻¹) in the recently contaminated soil and a reduction in hydrocarbon concentration (~30 %). The combination of an inert support and enzymatic and respirometric analyses made it possible to detect the different biodegradation capacities of the studied inocula and the natural attenuation potential of a recently contaminated soil at high hydrocarbon concentrations.

Keywords: Lipase. Dehydrogenase. Biodegradation. Natural attenuation
Morphology of Alloy Elements and Electrochemical Effects of Li4Ti5O12 /Graphene Produced by Ball Milling

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**ABSTRACT**

In the past two decades, many researchers focused their attention on metallic or semi-metallic elements which can alloy with lithium reversibly and release a high Li-storage capacity. The research samples of Li4Ti5O12/Graphene at hand were made with mechanical ball-milling technique (MA). Drops of graphene oxide were added to the powder of Li4Ti5O12, and thus enhanced the structural stability of the alloying. The main idea is to build a work electrode suitable for electrochemical test to be used in storage batteries. In order to deeply understand the behavior of graphene reaction in lithium, scanning electron microscopy (SEM) images were analyzed using algorithms from digital processing images. A complete characterization of alloying was also made, including X-Ray, transmission electron microscopy (TEM) and electrochemical noise (EN).

Keywords: Mechanical Alloying, Energy Storage Materials, Powder Metallurgy, Electrochemical Noise, Computer Simulations
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Electrochemical Performance of La2O3 /TiO2 and Effects of Ball Milling


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ABSTRACT

La2O3 powders were mixed with TiO2 powders to obtain a better alloy that can be used as energy storage. The influence of La2O3 with TiO2 was studied by electrochemical noise (EN); powders were made by ball milling, sintered and then characterized. The experimental results showed that the samples generated had a good response under NaOH; using EN technique in sintered samples and green samples (without sintering process). Solution samples had a disturbance response when adding Na2SO4. These results were conducted by using potentiodynamic polarization curves. Behaviors in potentiodynamic polarization curves showed a greater disturbance since lanthanum is a reactive material, but satisfactory results were obtained in complete curves. The X-ray diffraction (XRD) and (TEM) images presented an interesting structure and morphology to be used in order to clarify whether exist a pattern of behavior in samples made by ball milling, sintering process and milling time. The electrochemical studies and images obtained by TEM were also investigated. As a work electrode material, La2O3 doped with TiO2 had a good response at corrosion environment. The current results aimed at improving and designing a better electrode by researching degradation and their changes in microstructure.

Keywords: Mechanical Alloying, Electrochemical Noise, Morphology, Energy Storage Materials, Characterization.
**Vibrio Fischeri bioassay for Determination of Toxicity in petroleum contaminated soils from Tropical Southeast Mexico**

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\(^b\) Colegio de Postgraduados Campus Tabasco.

**ABSTRACT**

Using the Microtox bioassay toxicity was determined in 16 areas located in eight sites: In contaminated areas, in areas with natural recovery, after bioremediation and phytoremediation projects and in control areas (uncontaminated). These areas correspond to the following ecosystems: mangrove, fresh water swamp (Pachira aquatica), marsh and pasture (in the coastal plain and Pliocene-Pleistocene terraces). A significant toxicity was detected in uncontaminated or organic soils (22.2-49.1 toxicity units (TU)) which were comparable to levels found in hydrocarbon contaminated areas (22.3-42.0 TU). Generally, the toxicity in organic soils was much higher than that found in mineral soils (which was from below quantification levels to 9.3 TU). In an area restored by phytoremediation, the simple method used by Petróleos Mexicanos achieved recovery and superficial detoxification in the treated plot, exhibiting a toxicity reduction of 2.4 times with respect to untreated soil and a toxicity even slightly lower than the uncontaminated control in the same ecosystem (22.2 TU). Likewise, a bioremediation project in pasture resulted in a toxicity reduction down to levels comparable to uncontaminated soil (from below quantification levels to 7.9 TU). A tendency to decrease toxicity in organic soils during the rainy season was observed, toxicity drop in 80% of the areas sampled. Based on these findings, recommendations are presented for use of this test method in regional diagnostic studies.

Keywords: Bioremediation; contamination; ecotoxicology; oil
Evaluación de humedales artificiales de flujo libre y subsuperficial en la remoción de contaminantes de aguas residuales utilizando diferentes especies de vegetación macrófita.

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a Universidad Juárez Autónoma de Tabasco, División Académica de Ciencias Biológicas.

ABSTRACT

Las descargas de aguas residuales contienen altas cargas de turbiedad, color, sólidos suspendidos totales (SST), nitrógeno total (NT), fósforo total (PT), demanda química de oxígeno (DQO) y demanda bioquímica de oxígeno (DBO5), lo cual provoca daños a los ecosistemas acuáticos y terrestres. Por ello se deben reducir estas cargas contaminantes a niveles bajos para mitigar la contaminación de los ecosistemas. En el presente estudio se implementaron humedales artificiales de flujo libre operando con Typha domingensis (espadaño) y Eichhornia crassipes (jacinto de agua), y humedales de flujo subsuperficial empleando Paspalum paniculatum (camalote) y Cyperus articulatus L (chintul) para remover contaminantes del agua residual. Se implementaron también lagunas sin vegetación y lagunas con grava como controles. Se empleó un análisis no paramétrico de Kruskal-Wallis para evaluar diferencias significativas entre los cuatro tratamientos y los controles. El humedal que presentó la mayor eficiencia de remoción de contaminantes del agua residual fue el de flujo libre utilizando T. domingensis (eficiencias de remoción de turbiedad, color, DQO, DBO5, NT, PT y SST de 97,1; 83,4; 97,8; 97,5; 97,2; 91,1 y 97,7% respectivamente), seguido por el humedal de flujo subsuperficial empleando P. paniculatum con remociones de 94,8; 71,5; 94,7; 94,8; 92,7; 52,2 y 93,0% respectivamente. Los humedales de flujo libre empleando E. crassipes y de flujo subsuperficial que utilizó C. articulatus L presentaron las menores eficiencias de remoción de contaminantes. Los tiempos de retención hidráulica fueron de 5,5 y 7,5 días.

Keywords: Demanda Bioquímica se Oxígeno, Flujo Libre, Flujo Subsuperficial, Humedal Artificial, Vegetación Macrófita
Effect of Crude Petroleum on Water Repellency in a Clayey Alluvial Soil

D.C. Marin-García, R.H. Adams & R. Hernández-Barajas

ABSTRACT

Water repellency was studied in a clayey soil contaminated with light (36.6LAPI), medium (27.4LAPI), and heavy (15.0LAPI) crude oils at concentrations of 1, 2, 4, and 8 %. Higher water drop penetration times (WDPTs) were observed in dry soil as the density and concentration of petroleum increased, resulting in logarithmic functions which could be modeled from API gravity and oil concentration (R² = 0.986). WDPTs varied from 2.1 to 8.7 s with light crude, 11.1 to 44.9 s for medium crude, and 39.4 to 134.5 s for heavy crude. Only heavy crude-contaminated soil, at [2 % resulted in significant hydrophobicity. Critical moisture content in these hydrophobic soils was insignificant at moisture contents [12.8 % at 2 % heavy crude and [14.6 % at 4 % heavy crude. Only at a concentration of 8 % heavy crude was the critical moisture content ([17.2 %) higher than that observed in the field during the dry season (14.8 %). Thus, only (clayey) soil contaminated with very high concentrations of heavy oil is likely to present hydrophobicity in this monsoon climate. This study shows that the development of models to describe soil water repellency may be useful to propose remediation criteria which reduce or avoid the risk of water repellency.

Keywords: API Critical moisture content, Hydrophobicity, Oil contamination
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