Monosiphonous growth and cell-death in an unusual *Bostrychia* (Rhodomelaceae, Rhodophyta): *B. anomala* sp. nov.

John A. West¹*, Susan Loiseaux de Goër² and Giuseppe C. Zuccarello³

¹School of Botany, University of Melbourne, Parkville, VIC 3010, Australia  
²11 Rue des Moguerou, 29680 Roscoff, France  
³School of Biological Sciences, Victoria University of Wellington, P.O. Box 600, Wellington 6140, New Zealand

A morphologically distinct lineage within the *Bostrychia moritziana-B. radicans* species complex is described as a new species. *Bostrychia anomala* has thalli with branched monosiphonous filaments with apical cell divisions. The species has terminal tetrarosporangial stichidia, each subtending cell bearing tetrarosporangia with 2 cover cells. Discharged spores divide transversely, the lower cell first forming a narrow rhizoid and the upper cell forming a monosiphonous shoot. Females have subterminal procarps and males have terminal spermatangial stichidia. Carposporophytes are spherical. Isolates in culture show a pattern of cell death not associated with injury, reminiscent of programmed cell death. *Bostrychia anomala* shows cell death at intervals along the filaments resulting in division of adjacent cells on either side of the dead cell re-joining the filament; cell division of only one adjacent cell resulting in branching at that site; or filaments fragmenting at the cell death point with adjacent cells forming new apical cells, a means of thallus propagation. The cell death pattern could be a method of filament propagation in the mangrove environment where sexual reproduction is rare.

**Key Words:** *Bostrychia anomala* sp. nov.; monosiphonous; ‘non-fusion-division’; programmed-cell-death; Rhodomelaceae; sexual life history; vegetative propagation

INTRODUCTION

The biology of red algae in the genus *Bostrychia* (Rhodomelaceae) has been well studied over many years (reviewed in Zuccarello and West 2011). While the phylogeny and taxonomy have been clarified many questions still remain. One aspect is the highly diverse clade consisting mostly of algae identified as *Bostrychia moritziana* (Sonder ex Kützing) J. Agardh or *B. radicans* (Montagne) Montagne. This clade, designated the *B. moritziana-B. radicans* species complex, contains one morphologically distinct species, *B. pilulifera* Montagne, plus a parasite of *Bostrychia* (*Bostrychiolax australis* Zuccarello & West) (Zuccarello and West 2006). The other members of the clade consist of seven subclades of specimens resembling either *B. moritziana* or *B. radicans*, or subclades containing samples that can be identified as either (Zuccarello and West 1997, 2003, Zuccarello et al. 1999). It is clear that these subclades could be recognized as distinct species, based on genetic differentiation and reproductive incompatibility (spermatia attach to trichogynes but no carposporophytes are produced) (Zuccarello and West 2003, 2006). Data from crossing experiments suggest that even within these subclades reproductive incompatibility may be present (Zuccarello and West 1995, 2003, Zuccarello et al. 1999). Therefore based on the biological spe-
cies concept (Mayr 1942), species exist even within these subclades. As yet no consistent morphological character has been found to define any of the lineages within the *B. moritziana*-*B. radicans* species complex, except for the 2 above mentioned species. In a continuing attempt to clarify the taxonomy within this species complex we made detailed observations of some unusual isolates in culture.

The Rhodomelaceae, to which *Bostrychia* belongs, are polysiphonous, with a consistent and evolutionarily conserved mode of pericentral cell division (Hommersand 1963). Pericentral cells on *Bostrychia* are further transversely divided one or more times into tier cells (Hommersand 1963, King and Puttock 1989), in some species cortication is also evident (King and Puttock 1989). Sexual reproduction is by an alternation of isomorphic generations (*Polysiphonia*-type) with reproductive structures (tetraraphangia, spermangia, carpospores).

Programmed cell death (PCD), also known as apoptosis, while a well studied phenomenon in many organisms including plants (Van Doorn 2011) is poorly studied in red algae but it has been alluded to in the death of hair cells and trichoblasts, as well as formation of regular thallus perforations (Garbary et al. 2012). Cell repair, after artificial cell wounding, has also been studied in red algae (Kim et al. 1988, 1995, Kim and Fritz 1993). Kim et al. (1988) described three types of cell repair patterns (elongation type, fusion type, and non-fusion-type). A combination of both PCD and repair response has not previously been documented in red algae.

During our investigations of algae in the *Bostrychia moritziana*-*B. radicans* species complex we noticed unusual development in certain culture isolates maintained over years in culture and these isolates are in a unique molecular lineage. We describe these isolates as a new species within the *B. moritziana*-*B. radicans* species complex and document possible PCD in these strains.

**MATERIALS AND METHODS**

Methods for collection, isolation and maintenance of cultures are presented in West and Zuccarello (1999) and West (2005). To promote slower growth low nutrient levels were used initially (2 mL modified-Provasoli-media [MPM] enrichment per liter of sterile seawater) and 18-22°C, low light levels, <5 µmol photons m⁻² s⁻¹ cool white fluorescent or LED lighting at 12 : 12 LD daily cycle. The seawater was adjusted to 30 practical salinity units (psu) with Milli-Q water (Millipore Corp., Billerica, MA, USA). Careful observations with a dissecting stereomicroscope were made and short (1-4 mm) apices checked for contaminating epiphytes were excised with micro-forceps and subcultured in 50 × 70 mm crystallizing dishes containing 30 psu seawater medium with 10 mL MPM enrichment per liter. Most of these unialgal cultures were maintained in 18-22°C, 5-20 µmol photons m⁻² s⁻¹ cool white fluorescent or LED lighting at 12 : 12 LD daily cycle.

Photography was done using bright field optics on a Zeiss GFL microscope (Carl Zeiss, Jena, Germany) with a Canon G3 camera (Canon, Tokyo, Japan) and Photoshop CS to capture images. Aniline Blue stain (0.02%) in 50% Karo syrup was used to stain tetraraphangial stichidia of thalli fixed in 5% formaldehyde-seawater. All other images were of living specimens.

**Molecular analyses**

The methods for DNA extraction and amplification of *rbcL* are identical to those described in Zuccarello and West (2006). Sequences were edited (new Genbank accession numbers KC768865-KC768876), assembled and aligned using the Geneious 6.0 software package (Biomatters, http://www.geneious.com/). Alignment was straight forward as no gaps were found in the data set. Maximum-parsimony trees (MP) were constructed in PAUP* 4.0b10 (Swofford 2002), using the heuristic search option, 500 random sequence additions, tree-bisection-reconnection (TBR) branch swapping. Support for individual internal branches was determined by bootstrap analysis as implemented in PAUP*. For bootstrap analysis, 1,000 bootstrap data sets were generated from resampled data (10 random sequence additions, 1 million rearrangements per replicate). Maximum-likelihood trees (ML) were constructed in RAxML v.7.2.6 (Stamatakis 2006). Tree likelihoods were estimated with site specific general-time-reversible (GTR) and site specific rate heterogeneity (G) model for each codon position. Bootstrap support values were calculated with 1,000 replicates. Bayesian inference analysis was performed with MrBayes v3.1.2 (Ronquist and Huelsenbeck 2003). Analyses consisted of two independent runs of one cold and three incrementally heated chains, and 3 × 10⁶ generations with sampling every 100 generations. Posterior probabilities were calculated using a Metropolis-coupled Markov chain Monte Carlo approach. The log files of the runs were checked with Tracer v1.4.1 (Rambaut and Drummond 2007) and a burning sample of 1,000 trees was removed before calculating the majority rule consensus trees in MrBayes. All bioinformatic analyses with MrBayes were carried out on
the freely available Bioportal (http://www.bioportal.uio.no).

RESULTS

Phylogenetic analysis

The rbcL data set of 54 taxa consisted of 1,163 characters of which 430 were parsimony-informative. The MP / ML and Bayesian trees were congruent in all supported branches. The topology of the ML tree is shown in Fig. 1. The data clearly showed the seven lineages B. moritziana-B. radicans species complex, plus B. pilulifera, as presented previously (West et al. 2006, Zuccarello and West 2006), while support between lineages is poor. Lineage 2 is strongly supported and consists of three supported subclades. One of these lineages contains two isolates from the western Pacific (4613 and 4588), which displayed unusual morphology from their day of collection. This unusual morphology and the molecular data lead to us to propose a new species for this clade:

Fig. 1. Maximum-likelihood topology of rbcL sequences of members of the genus Bostrychia. Outgroups removed for clarity. The bootstrap values for maximum-parsimony trees (MP) (> 50%; right) and maximum-likelihood trees (ML) (≥ 50%; left) are given on each branch, and strongly supported branches (MP-bootstrap [BS] and ML-BS ≥ 95%) are indicated by asterisks. Bayesian inference values over 0.95 are shown by thicker branches. For further information on samples see West et al. (2006), Zuccarello and West (2006), and Zuccarello et al. (2012), except for newly derived sequences (underlined).
Bostrychia anomala J. A. West, S. Loiseaux de Goër & G. C. Zuccarello sp. nov.

Uniseriate filaments entirely monosiphonous with apical cell divisions, branching not apically derived but formed by lateral bud cells from intercalary cells or by single intercalary cell deaths followed by lateral growth of an adjacent cell. Tetrasporangial stichidia terminal with 2-4 segments, each segment bearing 2-3 tetrasporangia with 2 cover cells. Females with subterminal procarp and 3 sets of pericentral cells around the axial cell. Terminal cystocarps with a distinct ostiole. Males with terminal spermatangial stichidia. Cell death occurs at variable intervals along the filaments and results in: 1) 'non-fusion division' by adjacent cells on both sides rejoining the filament; 2) cell division of only one adjacent cell resulting in branching at that site; 3) filament fragmentation forming new thalli.

Type localities. Polysiphonous Bostrychia species and monosiphonous specimens with cells of similar appearance to those of Bostrychia were collected on mud and pneumatophores of the mangrove Sonneratia sp. associated with the palm Nypa fruticans (Thunberg) Wurmb., on Feb 8, 2006, near Okat Harbor (05°21.406’ N, 162°57.966’ E), Kosrae, Micronesia. No reproduction was observed on the monosiphonous specimens in the field. This solate (4613) is designated as the holotype. Isolate 4588 is designated as the paratype and was obtained on the monosiphonous filaments. Cell death may also take place in a cell at filament branch nodes (Fig. 3B). The cell adjacent to the dead basal cell of the lateral branch elongates forming a new cell that grows through the dead cell (Figs 2G & 3A-G). Within 1-2 days one or both adjacent cells elongate slightly (Fig. 3A), change from a vegetative cell to a meristematic cell with a darker red and denser protoplast that divides transversely and grows into the dead cell space (Fig. 3A-C). These new cells are similar to apical cells in the monosiphonous filaments. Cell death may also take place in a cell at filament branch nodes (Fig. 3B).

Holotype. Dried specimen from culture 4613. NSW 904958.

Paratype. Dried specimen from culture 4588. NSW 904960.

Holotype and paratype cultures. Isolates 4588 and 4613 are available at the Korean Marine Plants Collection, Chungnam National University, 220 Gung-dong, Yuseong-gu, Daejeon 305-764, Korea.

RcbL sequence of holotype: Genbank accession numbers KC768866

Filament growth and branching

The monosiphonous filaments are quite uniform with a cell diameter of 28-30 µm and cell length varying from 48-80 µm. Filament growth is by apical cell division (Fig. 2C). Each cell has a central nucleus, 8-10 µm in diameter, suspended in an axial cytoplasmic strand. Chloroplasts are purple to pink, discoid to oblong or polygonal (3-5 µm) and positioned in the peripheral cytoplasm and in the central axial strand. Lateral branching does not occur at the apex as seen in polysiphonous Bostrychia species but occurs from intercalary cells at various intervals along the filaments (Fig. 2A-C). Rhizoidal filaments are composed of thin elongate cells, these originate intercalarily and do not resemble other rhizoid types seen in this genus (e.g., cladohaptera) and occasionally show somewhat contorted growth (Fig. 2D & E).

Cell death and repair. Cell death is evident throughout the monosiphonous filaments. This phenomenon has been noticed over several years in these isolates and is a regular phenomenon. The regularity and numbers of cell death indicates that this is a due to a developmental process and is not due to injury. When a cell protoplast collapses a homogeneous green to brown colour appears within the dead cell (Figs 2G, H & 3A-G). A dark brown collar is seen at either end of the dead cell (Figs 2G & 3A-G). Within 1-2 days one or both adjacent cells elongate slightly (Fig. 3A), change from a vegetative cell to a meristematic cell with a darker red and denser protoplast that divides transversely and grows into the dead cell space (Fig. 3A-C). These new cells are similar to apical cells in the monosiphonous filaments. Cell death may also take place in a cell at filament branch nodes (Fig. 3B). The cell adjacent to the dead basal cell of the lateral branch elongates forming a new cell that grows through the dead cell (Figs 2H & 3B). The other adjacent cell in the main filament often does not change (Figs 2H & 3B).

In other cases, possibly when the position and distance between the adjacent cells change, the apical cell on one side will curve away from the axis of the filament (Fig. 3D) and form a new branch that can break away forming a new filament. When a filament breaks at a dead cell both cells adjacent to the dead cell become shoot tips of new filaments (Fig. 3E). Also if two or more cells in a sequence die the adjacent live cell divides, elongates laterally and forms a new shoot apex (Fig. 2G).

Tetrasporophytes. Terminal tetrasporangial stichidia are numerous (Fig. 4A). Development is initiated with the formation of a series of pericentral cells by 2-4 axial cells, adjacent to the apical cell (Fig. 4B & C). Often the apical cell resumes cell divisions and vegetative growth so that mature stichidia become intercalary (Fig. 4A). The pericentral cells divide transversely forming tier cells (Fig. 4B) like those of normal polysiphonous Bostrychia species. The lower cell serves as a stalk cell and the upper cell becomes a tetrasporangial initial. The stalk cell also divides
Fig. 2. *Bostrychia anomala* vegetative growth and cell death, 4613 (A-E, G & H) and 4588 (F). (A) Filaments with branch initials (bi) arising from intercalary cells and terminal tetrasporangial stichidium (t). (B) Lateral branch initial arising as a curved "lenticular" cell division from parent axis. (C) Lateral branch with actively dividing apical cell. (D) Paired rhizoids from intercalary cell. (E) Vegetative branches with many rhizoids. Cell deaths (cd) evident in one branch. (F) Many filaments with frequent cell death (cd). Collapsed green protoplast and dark brown collar around walls at both ends seen in many dead cells. (G) Sequence of 3 dead cells with collapsed protoplasts, tan colour around the walls and dark brown collars at ends of cells evident. (H) Cell death at base of lateral branch with possible rhizoid elongating toward the main filament on the left. Scale bars represent: A, E & F, 60 µm; B-D, G & H, 30 µm.
Fig. 3. Bostrychia anomala cell death, wound healing and branching, 4588 (A & B) and 4613 (C-G). (A) At each end of the dead cell (collapsed green protoplast and brown collars at either end visible), elongation and division of adjacent cells is seen. New cells with dense protoplast. (B) Cell death at lateral branch base with cell elongation of cell adjacent to dead cell, above, and a slight bulge of the cell adjacent on the main axis suggesting similar development. (C) Old cell wall visible with division of adjacent cells, connection with visible pit plug (arrow) and formation of lateral branch also visible. (D) Filament alignment slightly displaced, resulting in lower adjacent cell dividing to form new apical cell. (E) Cell death resulted in a broken filament, on left and right of central intact filament, and new apical cells at the ends of the broken filament. Old cell wall is visible (arrows). (F) After cell death cells adjacent to dead cell elongating. (G) Filament on left showing elongating cell above and below compressed dead cell; filament on right with disrupted connection at dead cell, a new shoot apex forming below, cell not visibly changed. Scale bars represent: A-G, 30 µm.
Fig. 4. *Bostrychia anomala* 4613 tetrasporophyte. (A) Terminal tetrasporangial stichidia. (B) Young tetrasporangial stichidium, apical cell (ac), first axial segment with pericentral cells (pc), middle segment with tier cells (tc). (C) Aniline-blue stained stichidium with developing tetrasporangia. (D) Aniline-blue stained stichidium with each segment forming 2-3 tetrasporangia and respective cover cells (arrows). (E) Live stichidium with 3 axial cell segments 2-3 tetrasporangia, each with 2 cover cells (arrows). (F) Sporeling with long rhizoidal filament (upwards) and shorter erect shoot (downwards). Scale bars represent: A-F, 30 µm.
Fig. 5. *Bostrychia anomala* 4613 female and male. (A) Subterminal procarp with elongating trichogyne (t). (B) Mature procarp on intercalary cell. (C) Mature procarp with very long trichogyne and sterile tier cells at either side of procarpic branch (darker cells). (D) Spermatangial stichidium. (E) Mature cystocarp with mature carposporophyte visible within pericarp. (F) Mature cystocarp slightly squashed to discharge carpospores through the terminal ostiole. Old trichogyne (t) visible on the lower right side of cystocarp. Scale bars represent A-F, 30 µm.
to form 1-2 cover cells that project out from the lower part of each mature tetrahedrally divided sporangium (68-77 µm diameter) (Fig. 4D & E). Discharged spores are about 30-36 µm diameter and the spores divide transversely once, the lower cell first forming a slightly narrow rhizoid and the upper cell secondarily forming a monosiphonous shoot (Fig. 4F). No pericentral cells were observed during vegetative growth of any sporelings.

Female gametophytes. Carpogonial branches develop on a subterminal cell (Fig. 5A) of the monosiphonous branches and the shoot elongates if no fertilization occurs and the procarps become intercalary (Fig. 5B & C). The female thalli did not persist in culture so consequently it was not possible to investigate the further details of procarp-carposporophyte development but it appears that the carpogonial branch base is partially enclosed by two sets of prominent sterile cells (Fig. 5C). Mature cystocarps of about 350 µm diameter were observed only twice with a well developed pericarp and terminal ostiole, producing about 40 carpospores (Fig. 5E & F).

Male gametophytes. Terminal spermatangial stichidia are about 50 µm wide and up to 400 µm long (Fig. 5D). These stichidia are quite similar to the spermatangial stichidia borne on monosiphonous laterals of some polysiphonous B. moritziana (King and Puttock 1989).

The monosiphonous thalli of isolate 4588 showed no spore reproduction in field or culture specimens. Propagation in culture resulted entirely from cell death and breakage along the filaments producing many short filaments. This isolate has slightly smaller cells than isolate 4613 (22-26 µm diameter and 46-53 µm long).

**DISCUSSION**

The consistent morphology of these unusual isolates and their phylogenetic position as a well-supported lineage within the *Bostrychia moritziana-B. radicans* species complex warrants that they be described as a unique species of *Bostrychia*. Finding morphological characters for the growing number of ‘molecular species’ (i.e., species recognition based solely on molecular distinctness) continually being identified in red algae is problematic for taxonomy and field identification. Part of the problem lies with the shortage of characters available in many algal genera. In *Bostrychia*, this problem is acutely seen. There are an extremely limited number of characters to identify species (King and Puttock 1989, Zuccarello and West 2006) leading to many polyphyletic species that cannot be described (*B. simpliciuscula* Harvey ex J. Agardh) or monophyletic but highly diverse species complexes (*B. moritziana-B. radicans*) (Zuccarello and West 2006, in this paper). Our ability to collect and culture many isolates combined with careful observations, has at least resolved a morphologically consistent evolutionary lineage in this case. Monosiphony has occasionally been observed in 27 other culture isolates (Table 1). In all cases monosiphony is short-lived and isolates revert to polysiphony, or switch back and forth. These occasionally monosiphonous isolates are found in several lineages of the *B. moritziana-B. radicans* species complex but mostly in lineage 2 with 42% and lineage 7 with 30%.

Isolates 4588 and 4613 were the only field samples we observed to be monosiphonous and have remained so in culture for 7 years. The molecular evidence and reproductive characters were essential in linking *B. anomala* to the *B. moritziana-B. radicans* species complex.

### Table 1. Isolates of **Bostrychia moritziana-B. radicans** in which monosiphonous filaments are occasionally seen

<table>
<thead>
<tr>
<th>Isolate No.</th>
<th>Collection location</th>
<th>Lineage*</th>
</tr>
</thead>
<tbody>
<tr>
<td>3001</td>
<td>Pohnpei, FSM</td>
<td>2</td>
</tr>
<tr>
<td>3453</td>
<td>Sulawesi, Indonesia</td>
<td>2</td>
</tr>
<tr>
<td>4110</td>
<td>Sabah, Malaysia</td>
<td>2</td>
</tr>
<tr>
<td>4125</td>
<td>Florida, USA</td>
<td>6</td>
</tr>
<tr>
<td>4156</td>
<td>New Caledonia</td>
<td>7</td>
</tr>
<tr>
<td>4157</td>
<td>New Caledonia</td>
<td>7</td>
</tr>
<tr>
<td>4158</td>
<td>New Caledonia</td>
<td>2</td>
</tr>
<tr>
<td>4159</td>
<td>New Caledonia</td>
<td>2</td>
</tr>
<tr>
<td>4160</td>
<td>New Caledonia</td>
<td>7</td>
</tr>
<tr>
<td>4161</td>
<td>New Caledonia</td>
<td>7</td>
</tr>
<tr>
<td>4162*</td>
<td>New Caledonia</td>
<td>7</td>
</tr>
<tr>
<td>4278</td>
<td>Tamil Nadu, India</td>
<td>7</td>
</tr>
<tr>
<td>4367</td>
<td>New Caledonia</td>
<td>2</td>
</tr>
<tr>
<td>4368</td>
<td>New Caledonia</td>
<td>1</td>
</tr>
<tr>
<td>4537</td>
<td>Vanuatu</td>
<td>2</td>
</tr>
<tr>
<td>4385</td>
<td>QLD, Australia</td>
<td>7</td>
</tr>
<tr>
<td>4408</td>
<td>Bahia, Brazil</td>
<td>7</td>
</tr>
<tr>
<td>4442</td>
<td>Madagascar</td>
<td>1</td>
</tr>
<tr>
<td>4591</td>
<td>Pohnpei, FSM</td>
<td>2</td>
</tr>
<tr>
<td>4597</td>
<td>Pohnpei, FSM</td>
<td>6</td>
</tr>
<tr>
<td>4609</td>
<td>Kosrae, FSM</td>
<td>2</td>
</tr>
<tr>
<td>4611</td>
<td>Kosrae, FSM</td>
<td>7</td>
</tr>
<tr>
<td>4619</td>
<td>Kosrae, FSM</td>
<td>2</td>
</tr>
<tr>
<td>4630</td>
<td>Chuuk, FSM</td>
<td>2</td>
</tr>
<tr>
<td>4631</td>
<td>Chuuk, FSM</td>
<td>7</td>
</tr>
<tr>
<td>4633</td>
<td>Chuuk, FSM</td>
<td>2</td>
</tr>
<tr>
<td>4634</td>
<td>Chuuk, FSM</td>
<td>2</td>
</tr>
</tbody>
</table>

*FSM, Federated States of Micronesia; QLD, Queensland.
*Lineages assignment within the *B. moritziana-B. radicans* species complex (Zuccarello and West 2006) based on RuBisCo spacer sequencnes.
A most unusual feature of *B. anomal* is the regular pattern of cell death in this species. PCD has not been studied in red algae although it has been hypothesized in various red algal developmental events (e.g., trichoblasts abscission, thallus perforations) but no definitive molecular information was obtained (Garbary et al. 2012). As cell death in *B. anomal* often leads to the fragmentation of the filament it could be an effective means of vegetative propagation. Mangrove-associated *Bostrychia* species are often vegetative in the field, although in culture they can produce sexual or asexual structures (West and Zuccarello 1999). Asexual reproduction of lineages with the *B. moritziana-B. radicans* species complex is common in some regions and does not seem to affect the ability of these populations to maintain large population sizes (West et al. 1992, West and Zuccarello 1999). Cell death and subsequent filament propagation could give *B. anomal* a competitive advantage in certain environments.

When filaments do repair they mostly follow a pattern, recognized as the “non-fusion-type” as proposed by Kim et al. (1988). Cell division is initiated in the cells adjacent to the dead cell and the elongating cells abut within the cytoplasmic space of the dead cell. The cells newly in contact must be able to adhere as the filament is not weaker at this location. Both PCD and wound repair are phenomena in red algae that warrant increased scientific research.

Our data clearly indicates that an evolutionary lineage within the *B. moritziana-B. radicans* species complex has consistent morphological characters that warrant its description as an identifiable species, *B. anomal*. These isolates also have unusual cellular development that should be further explored.

ACKNOWLEDGEMENTS

This research was sponsored partially by various Australian Research Council grants from 1994-2000, a grant from the Australian Biological Resources Study (2002-2005) and the Hermon Slade Foundation (2003-2007). Many thanks to Alan Millar for the herbarium curation.

REFERENCES


Zuccarello, G. C., Kamiya, M., Ootsuki, R., Loiseaux de Goër,


