Janet Jennifer Luangsa-ard
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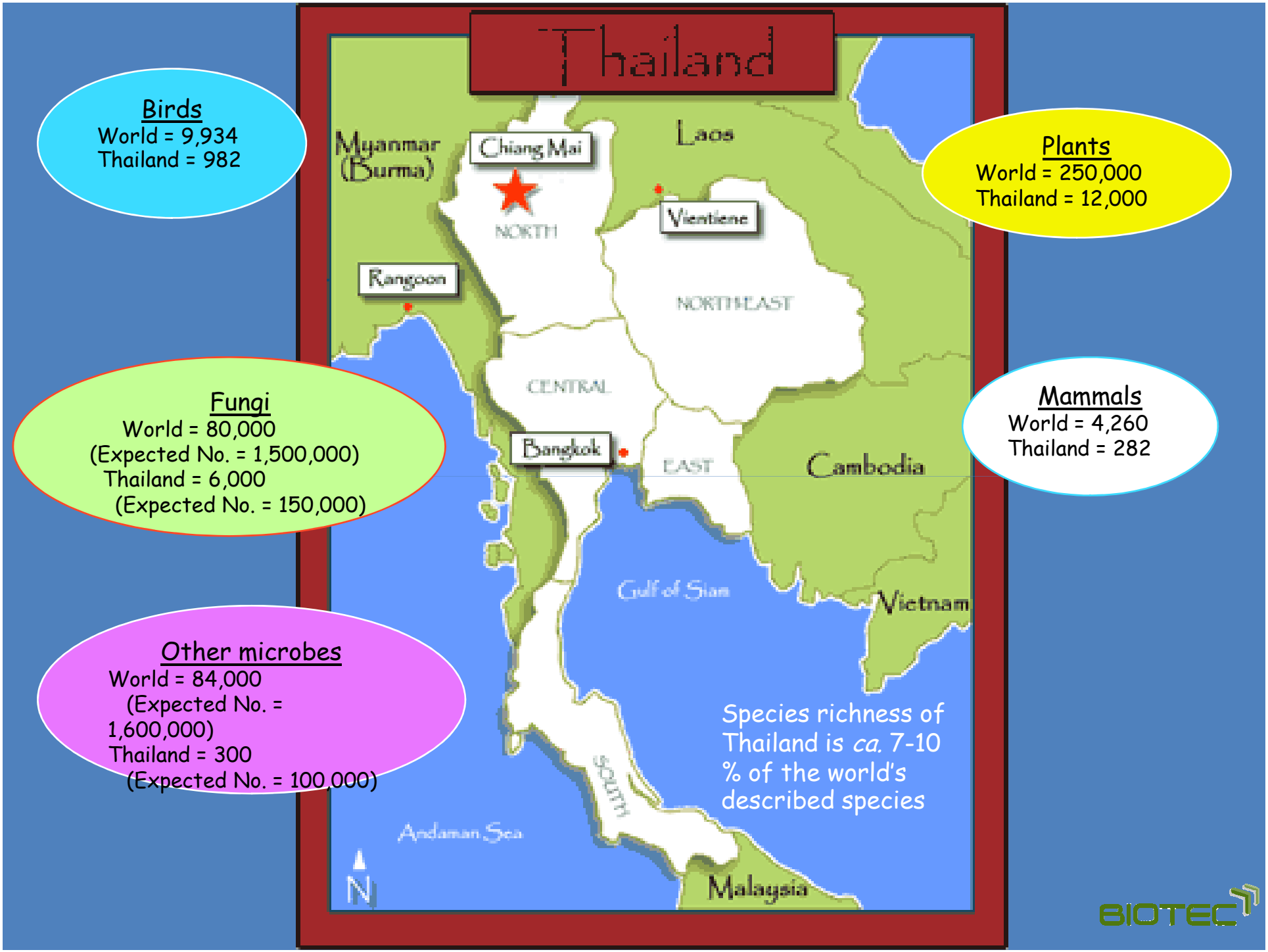
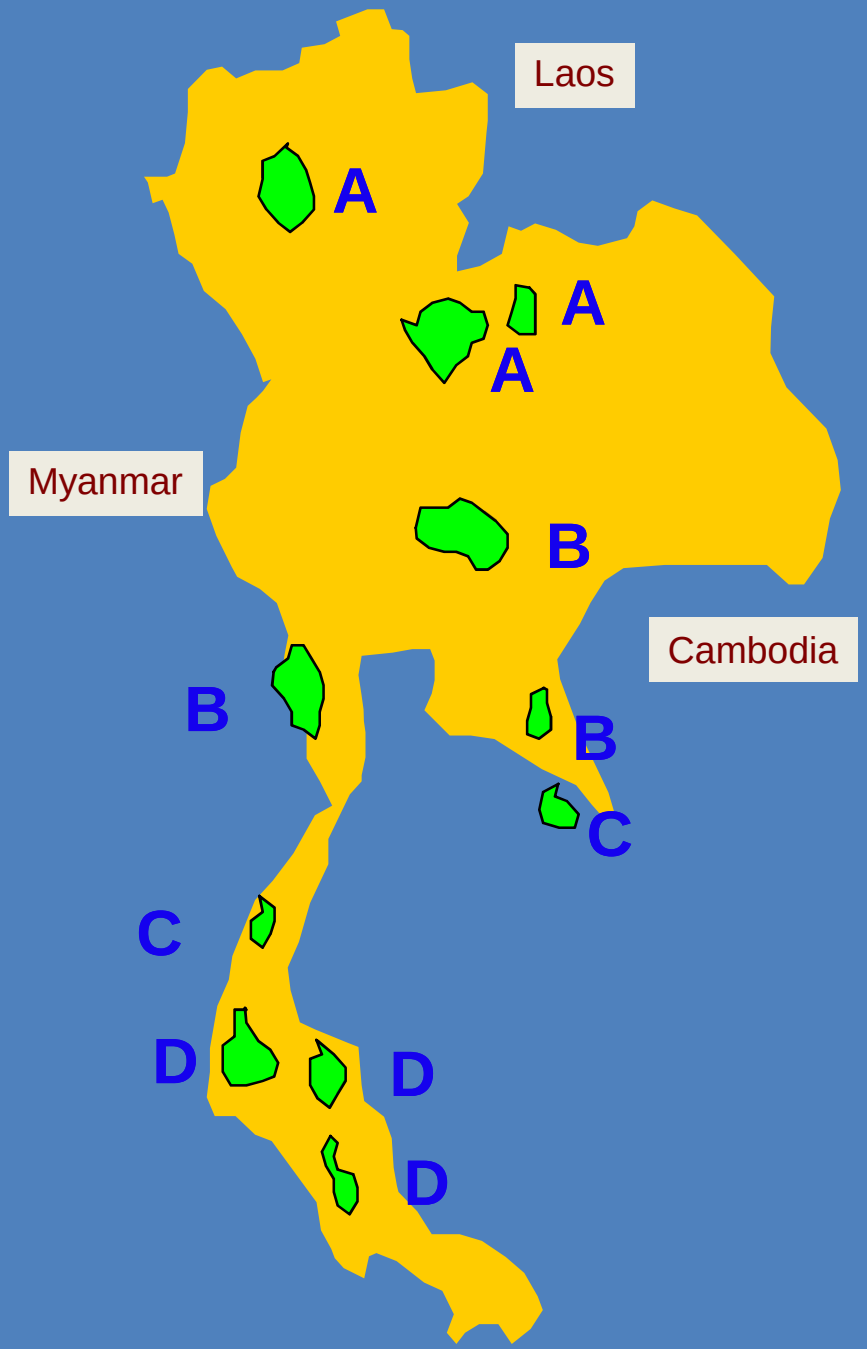
1 April 2013
NAC 2013


Thailand
Birds
World = 9,934
Thailand = 982
Plants
World = 250,000
Thailand = 12,000
Fungi
World = 80,000
(Expected No. = 1,500,000)
Thailand = 6,000
(Expected No. = 150,000)
Mammals
World = 4,260
Thailand = 282
Other microbes
World = 84,000
(Expected No. = 1,600,000)
Thailand = 300
(Expected No. = 100,000)
Myanmar (Burma)
Chiang Mai
Laos
Vientiene
NORTH
Rangoon
NORTHEAST
CENTRAL
Bangkok
EAST
Cambodia
Gulf of Siam
Vietnam
SOUTH
Andaman Sea
Malaysia
N
Species richness of Thailand is ca. 7-10 % of the world's described species
BIOTEC



FOREST TYPES

A. Cool deciduous teak and pine forest

B. Evergreen monsoon forest

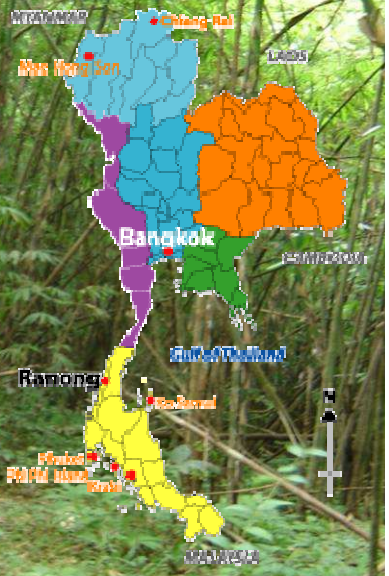
C. Coastal evergreen rain forest

D. Hill evergreen rain forest

BIOTEC

Survey and collection

Wildlife Sanctuaries
National Parks



Thailand Network on Culture Collections (TNCC) was established since 2000. The network consists of four major collections specialized in different groups of microorganisms:

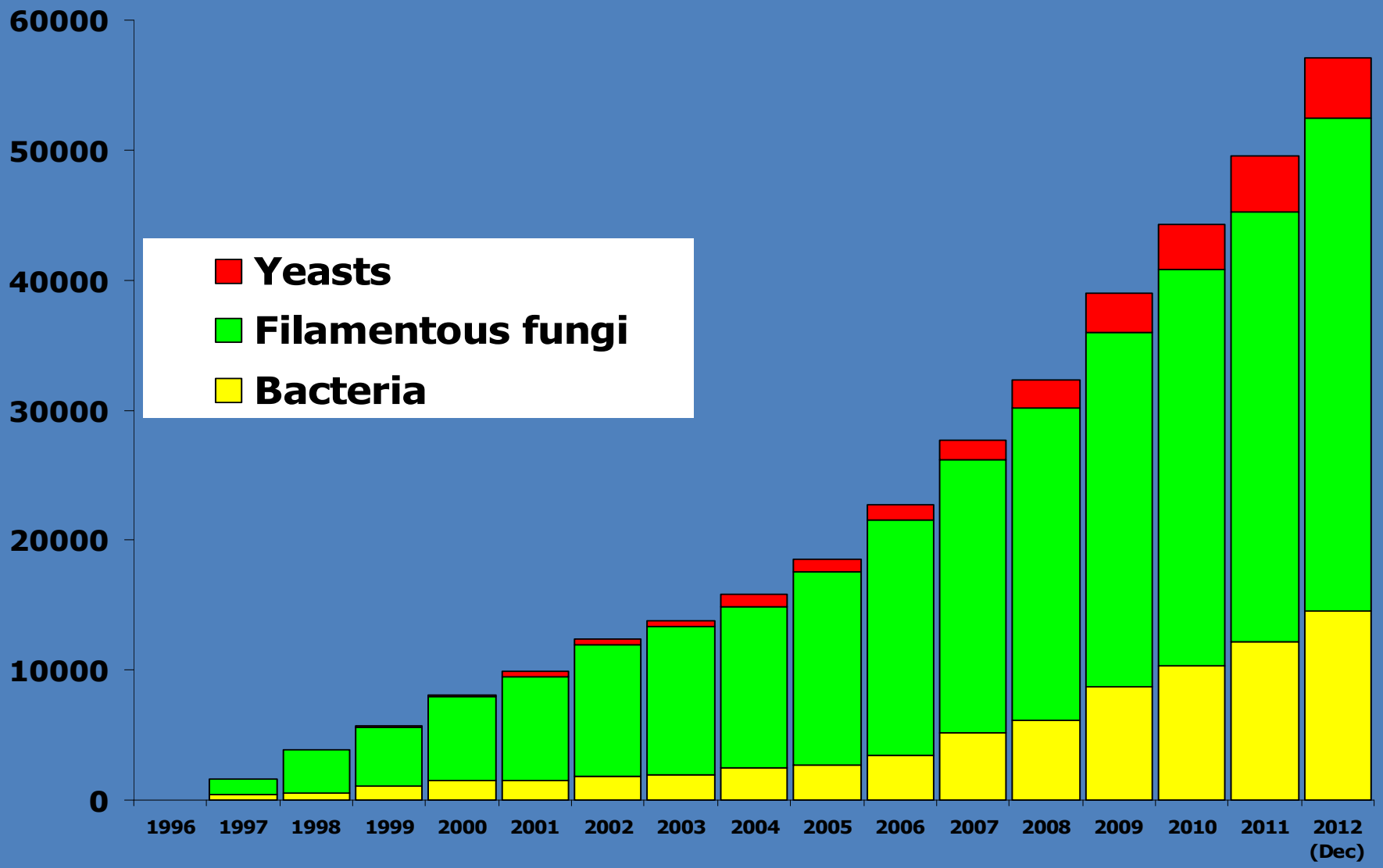
1) BIOTEC Culture Collection (BCC) holds more than 57,000 strains (1,896 species of 984 genera) of filamentous fungi, yeasts and bacteria isolated from natural environments in Thailand.

2) DMST Culture Collection (DMST) has in the collection 32,000 strains of filamentous fungi, yeasts, bacteria and cell lines related to human disease control and prevention.

3) DOA Culture Collection (DOA) houses more than 6,000 strains of agriculturally important algae, bacteria and filamentous fungi.

4) TISTR Culture Collection (TISTR) collects more than 5,500 strains of agriculturally and industrially useful algae, bacteria, filamentous fungi and yeasts.

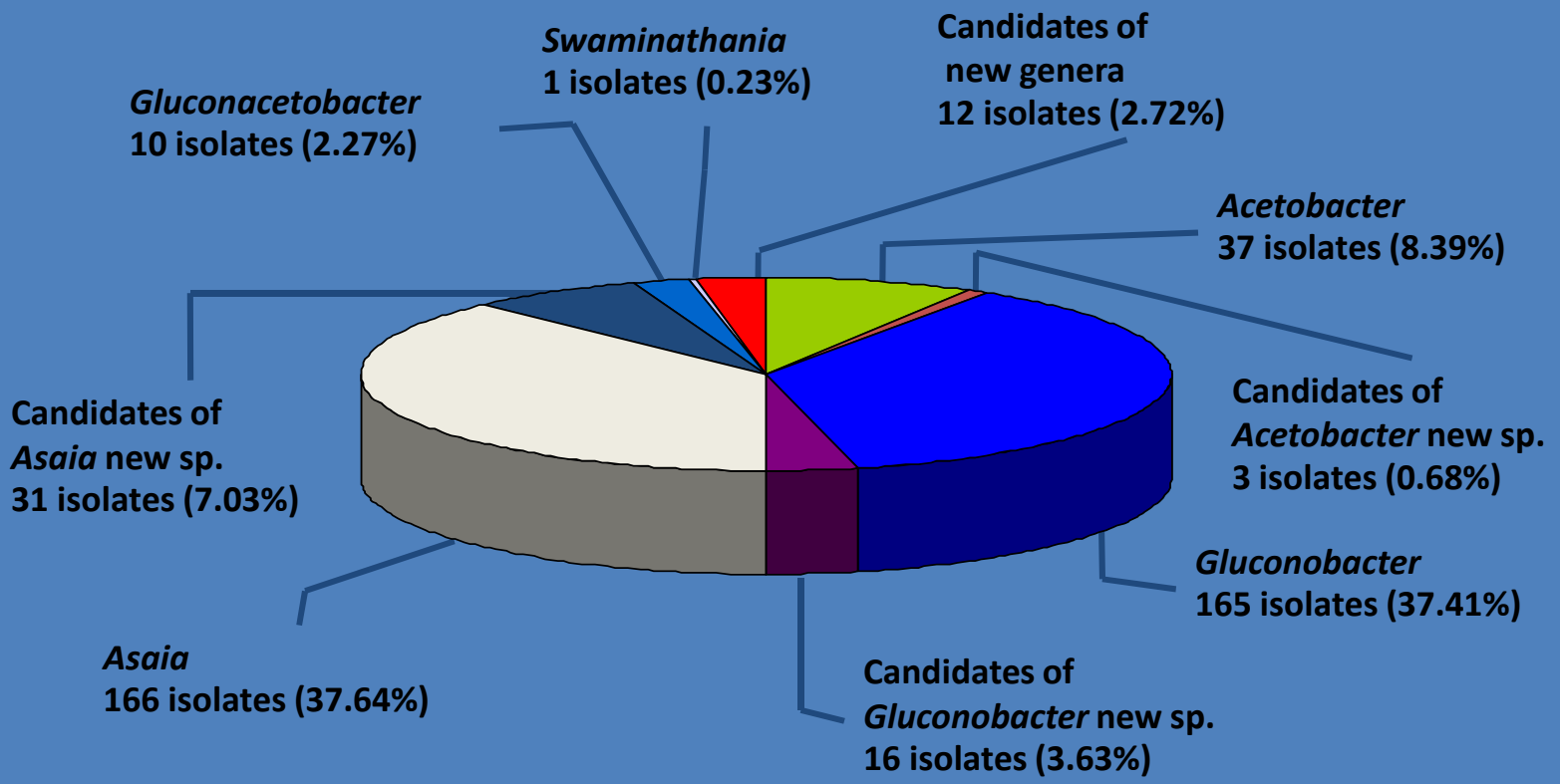
The number of microorganisms at BCC (57,079 samples)



BCC holdings

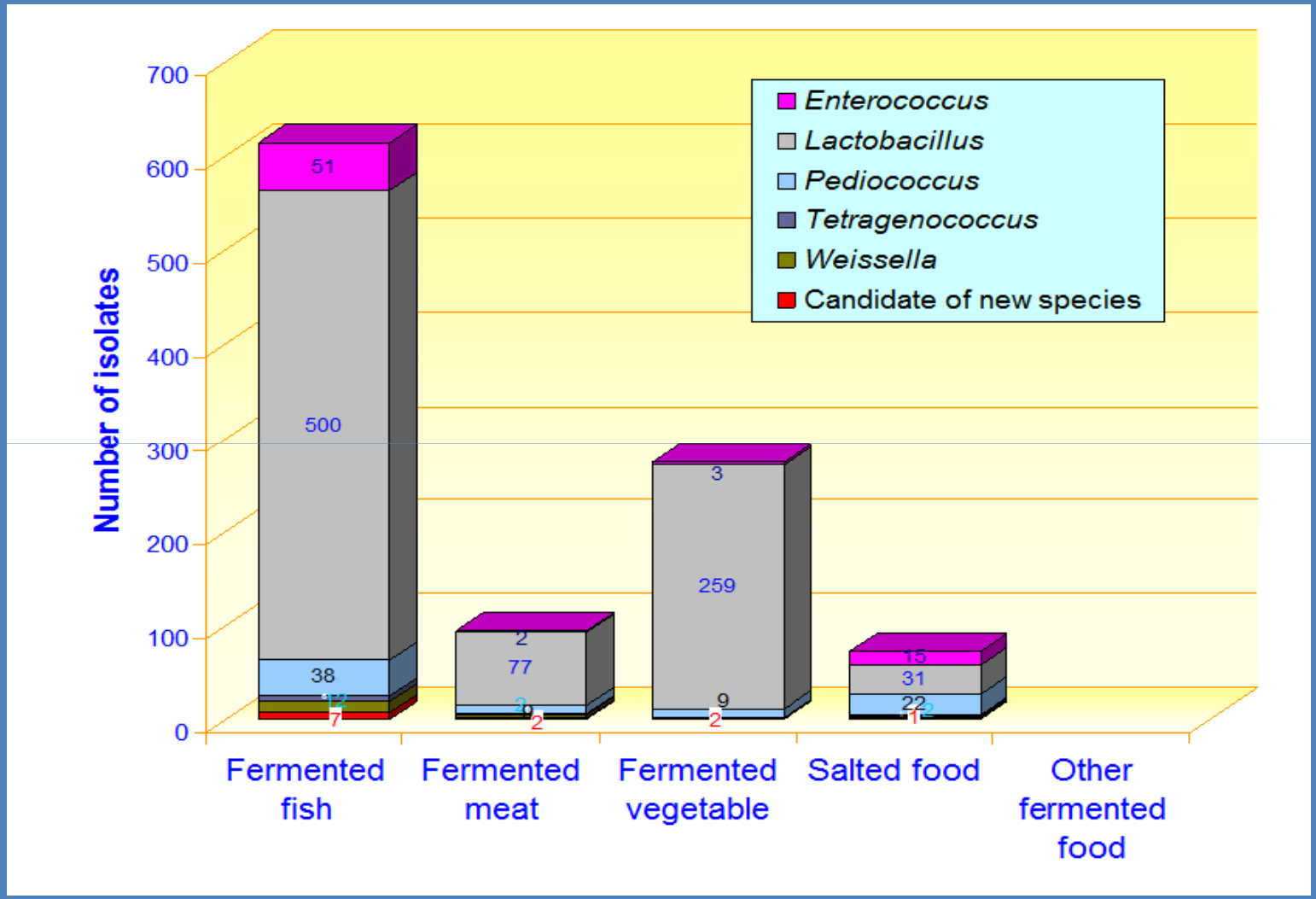
Group	No. strains	No. genera	No. species
Bacteria	14,561	155	424
Filamentous fungi	38,012	767	1,158
Yeasts	4,621	62	314
Total	57,194	984	1,896

Taxonomic study of acetic acid bacteria in Thailand



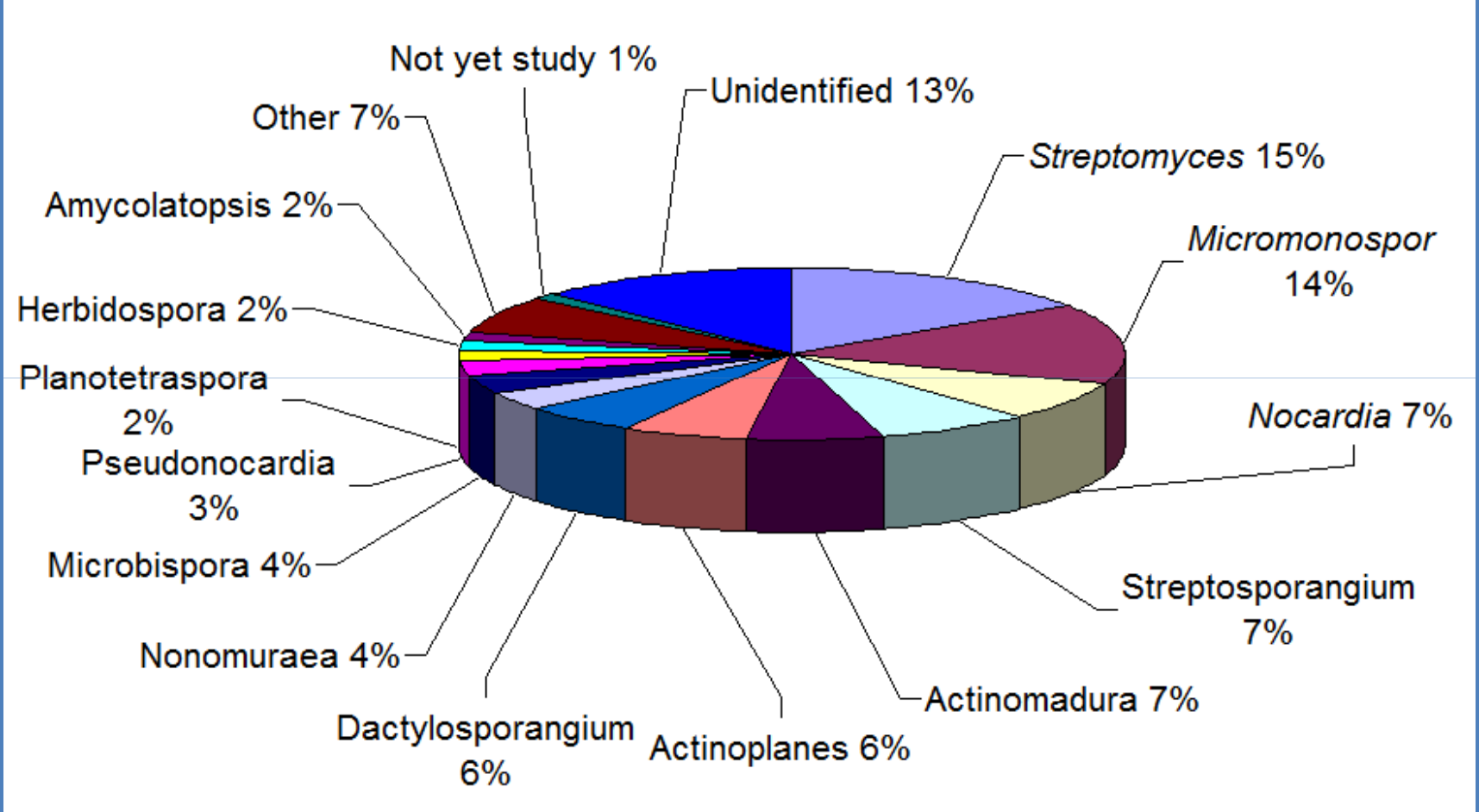
441 strains of acetic acid bacteria from natural sources collected in Thailand

Taxonomic and ecological study of lactic acid bacteria from fermented foods in Thailand



1,053 strains of lactic acid bacteria from fermented food isolated since 2008

Filamentous actinomycetes isolated from Thailand for bioactive compound screening

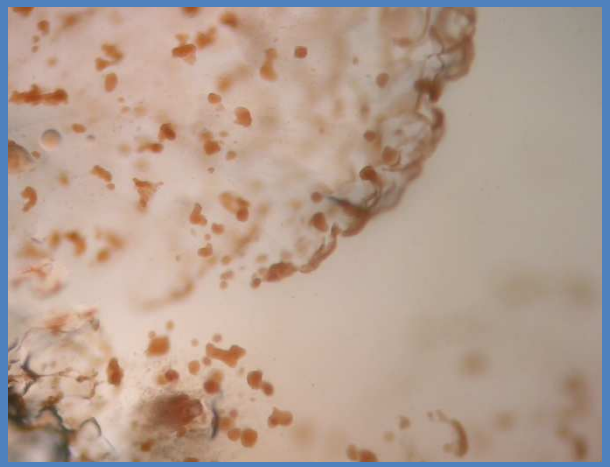


7,984 strains of 43 genera isolated since 2005

Myxobacteria isolated from Thailand for bioactive compound screening

Stigmatella

Condromyces



Nannocystis

Myxococcus

Corallococcus

Angiococcus

Cystobacter

105 strains of 7 genera isolated since 2008

Fungi

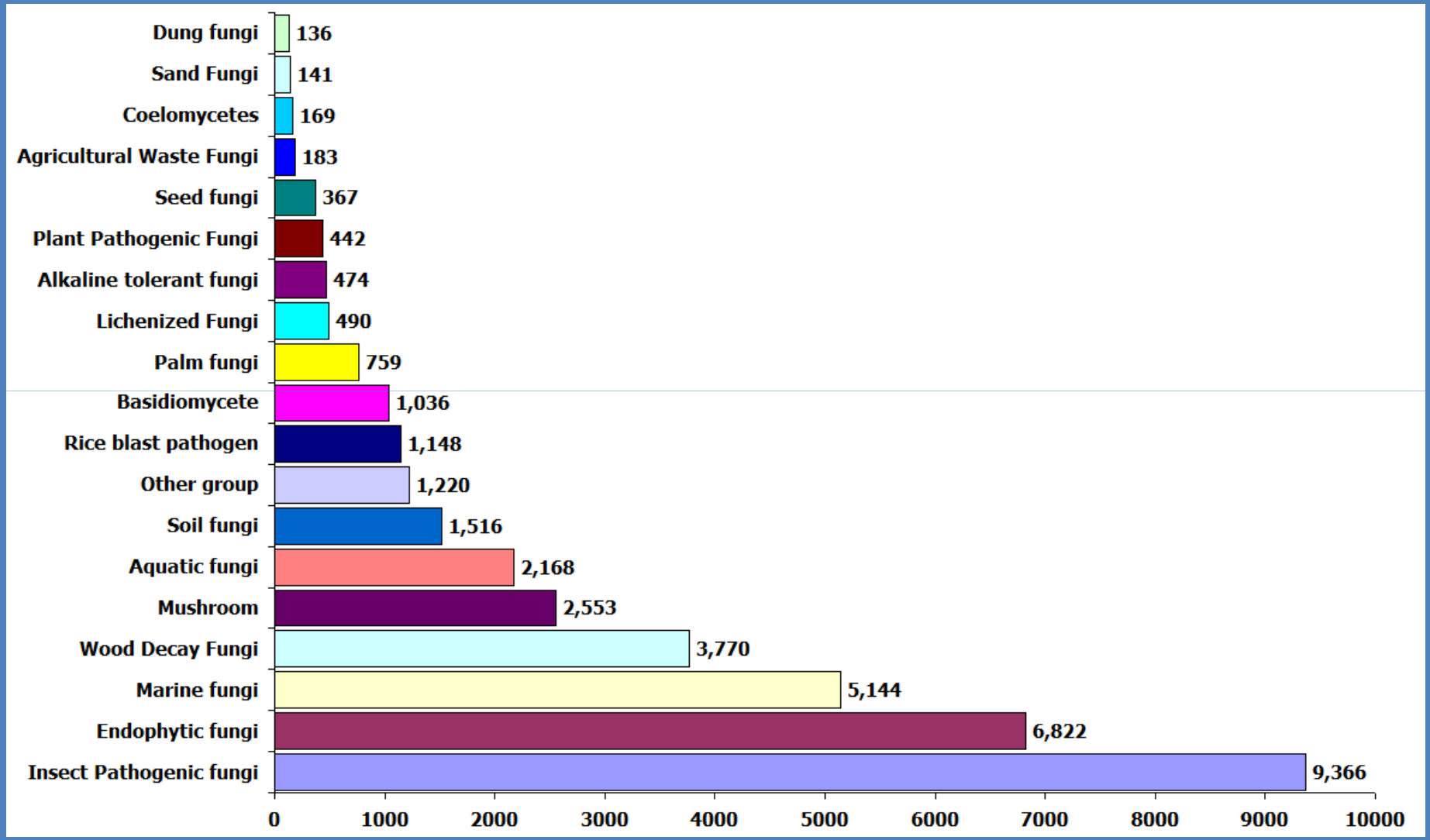



In 1989, BIOTEC started a research on insect-pathogenic fungi. This became a BIOTEC program in 1993 which now concentrates on several taxonomic and ecological fungal groups:

- **Alkalinophilic fungi**
- **Basidiomycetes**
- **Coelomycetes**
- **Endophytes**
- **Dothideomycetes**
- **Dung fungi**
- **Freshwater and Aquatic fungi**
- **Invertebrate-pathogenic fungi**
- **Lichens**
- **Marine fungi**
- **Palm fungi**
- **Plant pathogenic fungi**
- **Seed decay and leaf litter fungi**
- **Thermophilic fungi**
- **Yeasts**

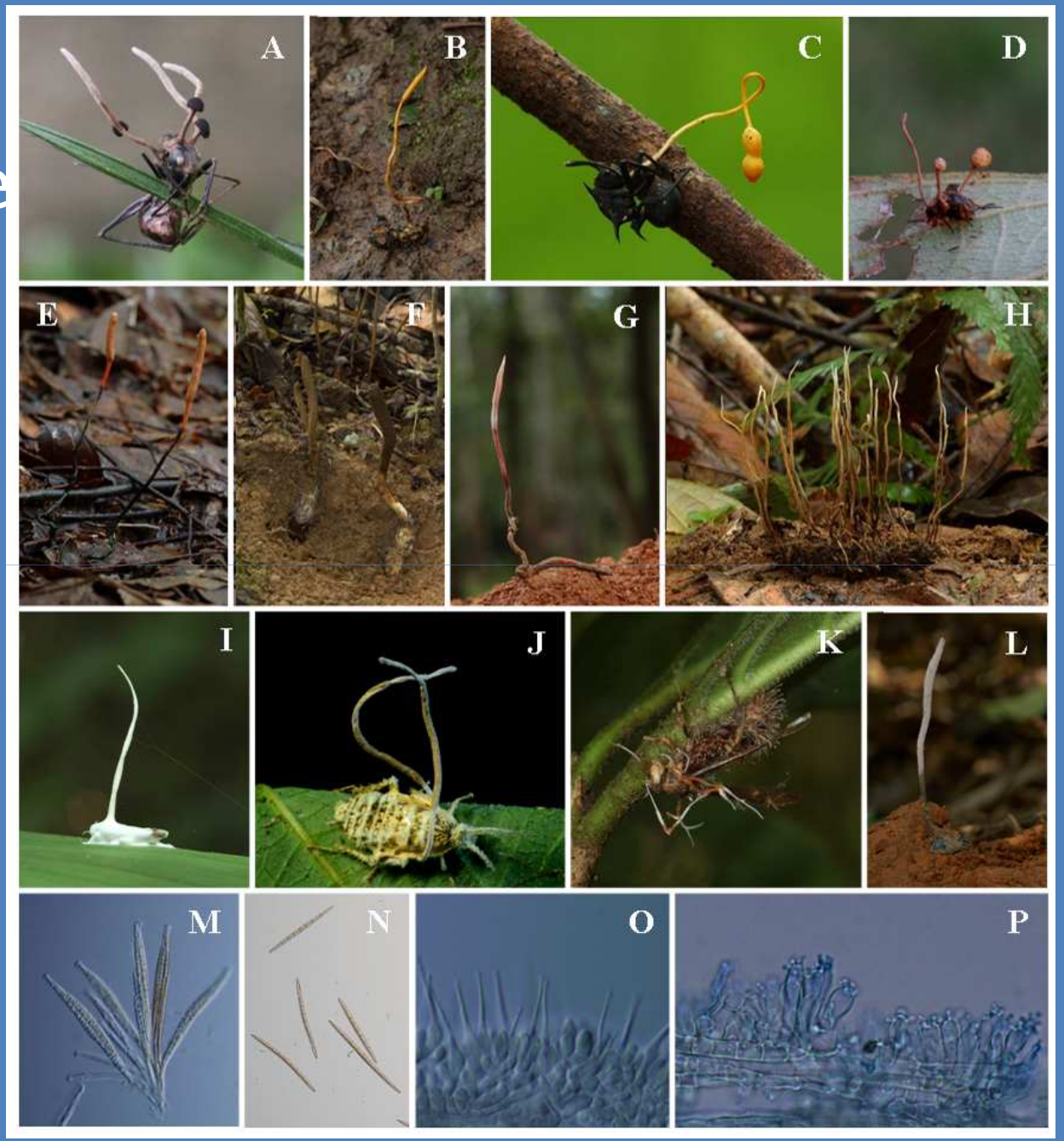
A total of 500-700 species of fungi had been recorded by the late 1980's while this figure now stands at around 6,000 species (Jones *et al.* 2004).

Group of Fungi in BIOTEC Culture Collection (38,012 Samples)

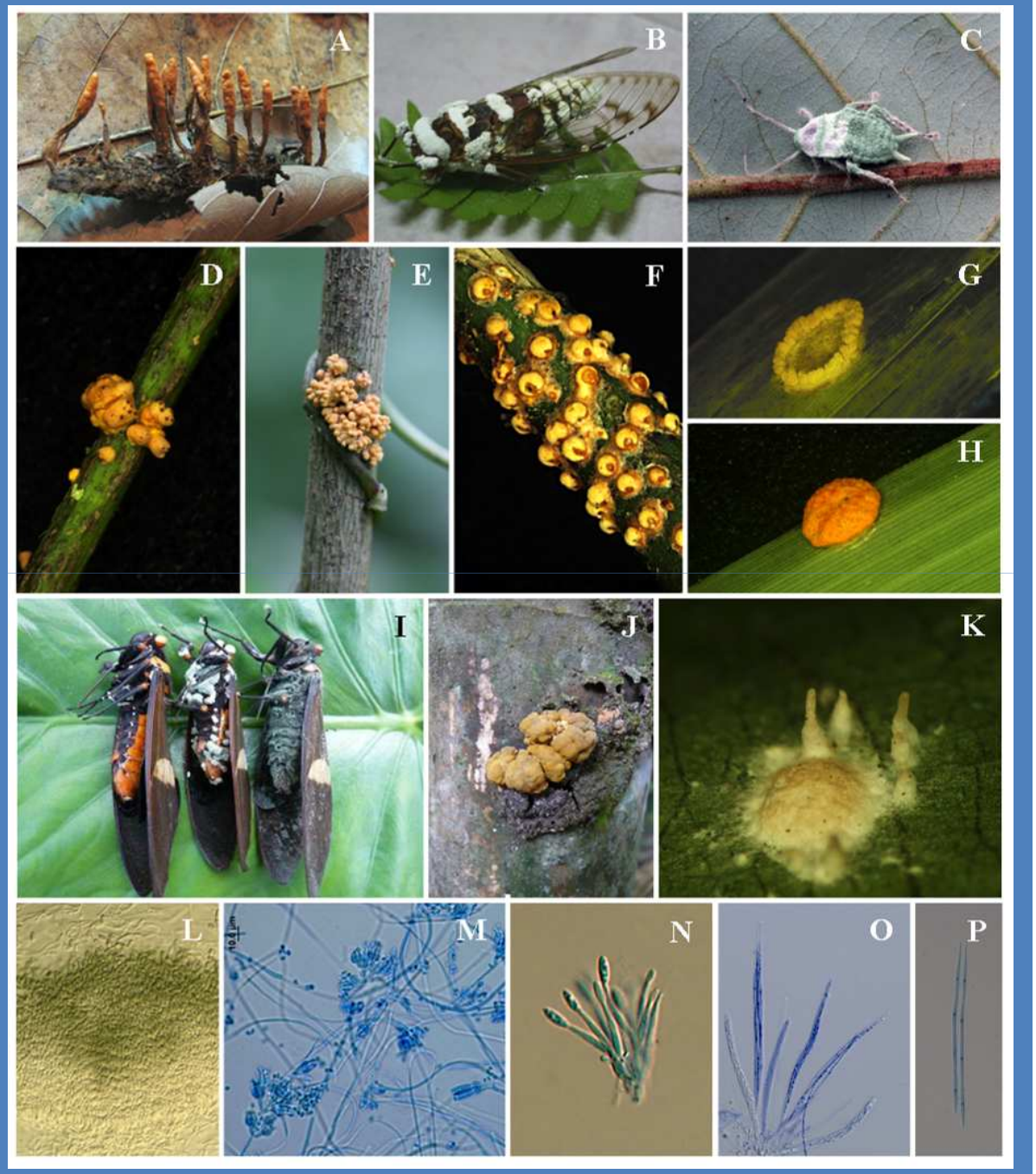


Cordycipitaceae

Ophio-cordycipitaceae



Clavicipitaceae



Host specificity

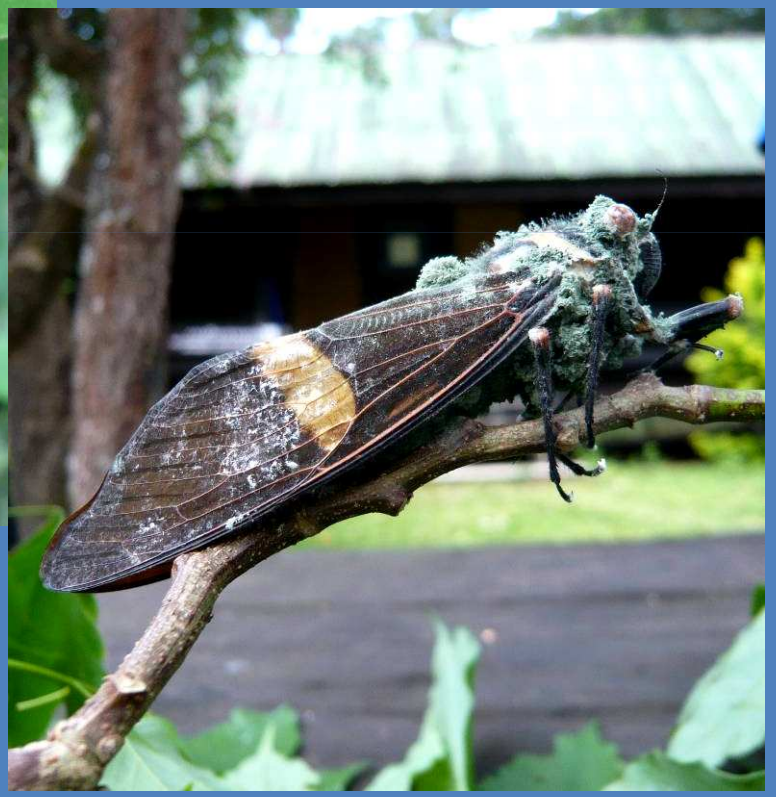
- General opportunistic pathogens
- Fastidious pathogens

Habitats

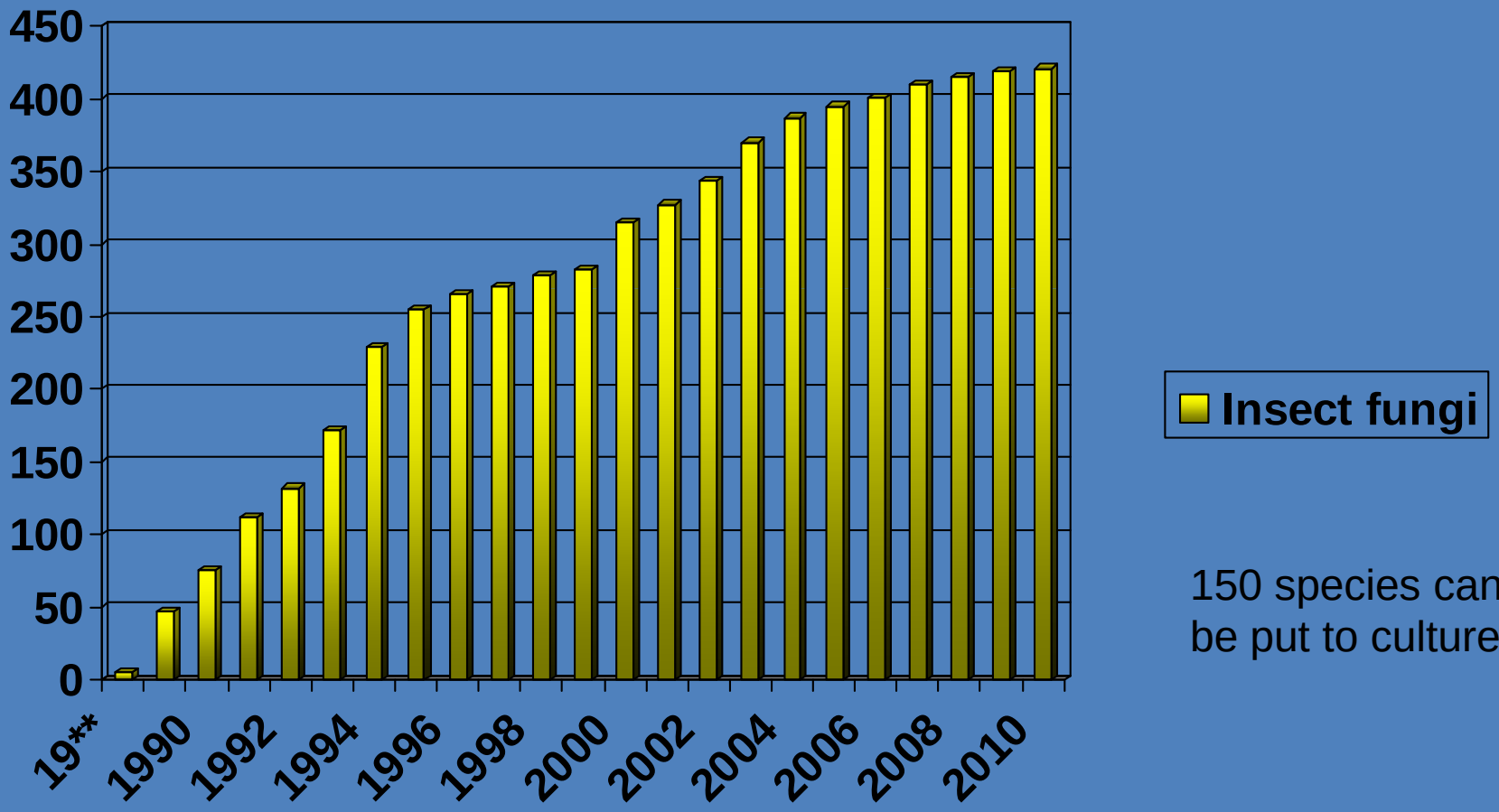
Habitats

Habitats

Habitats



Numbers of Insect Fungi in Thailand



150 species can be put to culture

BIOTEC

Acc. Chem. Res. 2005, 38, 813–823

Bioactive Substances from Insect Pathogenic Fungi

MASAHIKO ISAKA, PRASAT KITTAKOOP, KANYAWIM KIRTIKARA, NIGEL L. HYWEL-JONES, AND YODHATHAI THEBTARANONTH*

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Received March 7, 2005

ABSTRACT

Insect pathogenic fungi have opened up a relatively untapped area of natural product research which, unfortunately, has not received much attention to date. Found in wild abundance in wet tropical Thailand, the insect fungi are shown to contribute not only as controllers of insect populations but also as rich sources of structurally novel biologically active substances.

- Phomalactone – common in various family and genera
- Oosporein - common in various family and genera
- Beauvericin - 7 strains, Coleopterans and lepidopterans
- Cordytropolone – only from *Cordyceps*

FIGURE 3. Excavation revealing the larval host of *Cordyceps sinensis*.

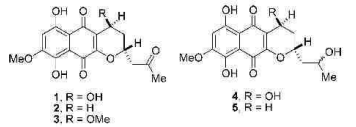
FIGURE 4. *Cordyceps sinensis* stroma on Lepidoptera larvae.

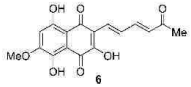
FIGURE 5. *Cordyceps unilateralis* on an ant.

derivatives, **1**–**6**. Interestingly, these naphthoquinones exhibited antimalarial activity with IC_{50} values of 2.5–10.1 μg/mL (Table 1). The above naphthoquinones show a

FIGURE 6. *Cordyceps nipponica* on ant lions.

deep red color under acidic conditions but intense purple in basic environments; such color characteristics are attractive to the pigment industry. Production of naphthoquinones by *C. unilateralis*, after optimization of fermentation conditions, can attain yields up to 3 g/L of culture broth.[28]





Cordyceps nipponica was originally described from cicadas in Japan and is found infecting both cicadas and ant lions (*Neuroptera*) in Thailand. Two *N*-hydroxy-2-pyridones, cordypyridones A (**7**) and B (**8**), and two tricyclic *N*-methoxy-2-pyridones, cordypyridones C (**9**) and D (**10**), were isolated from *Cordyceps nipponica* BCC 1389 (collected from Khao Yai National Park, central Thailand, Figure 6).[29] Cordypyridone A (**7**) is identical to 8-methyl-pyridoxatin, previously isolated from an unidentified fungus OS-F61800,[30] while its atropisomer, cordypyridone B (**8**), was shown to be a metabolite of BCC 1389. A careful study indicated that interconversion between compounds **7** and **8** occurred upon heating the solution, and the absolute configuration of cordypyridone **7** (and hence its atropisomer, **8**) was later determined using chemical means. Epoxidation of compound **11** (1-*O*-methyl derivative of **7**) and subsequent cyclization gave the major product **12**, which is the 14-hydroxy derivative of cordypyridone C (**9**). X-ray analysis of **13**, the *p*-bromobenzolate derivative of **12**, revealed the proposed absolute configuration. Cordypyridones A (**7**) and B (**8**) exhibited potent antimalarial activity with respective IC_{50}

Conoideocrellide A

JOURNAL OF NATURAL PRODUCTS

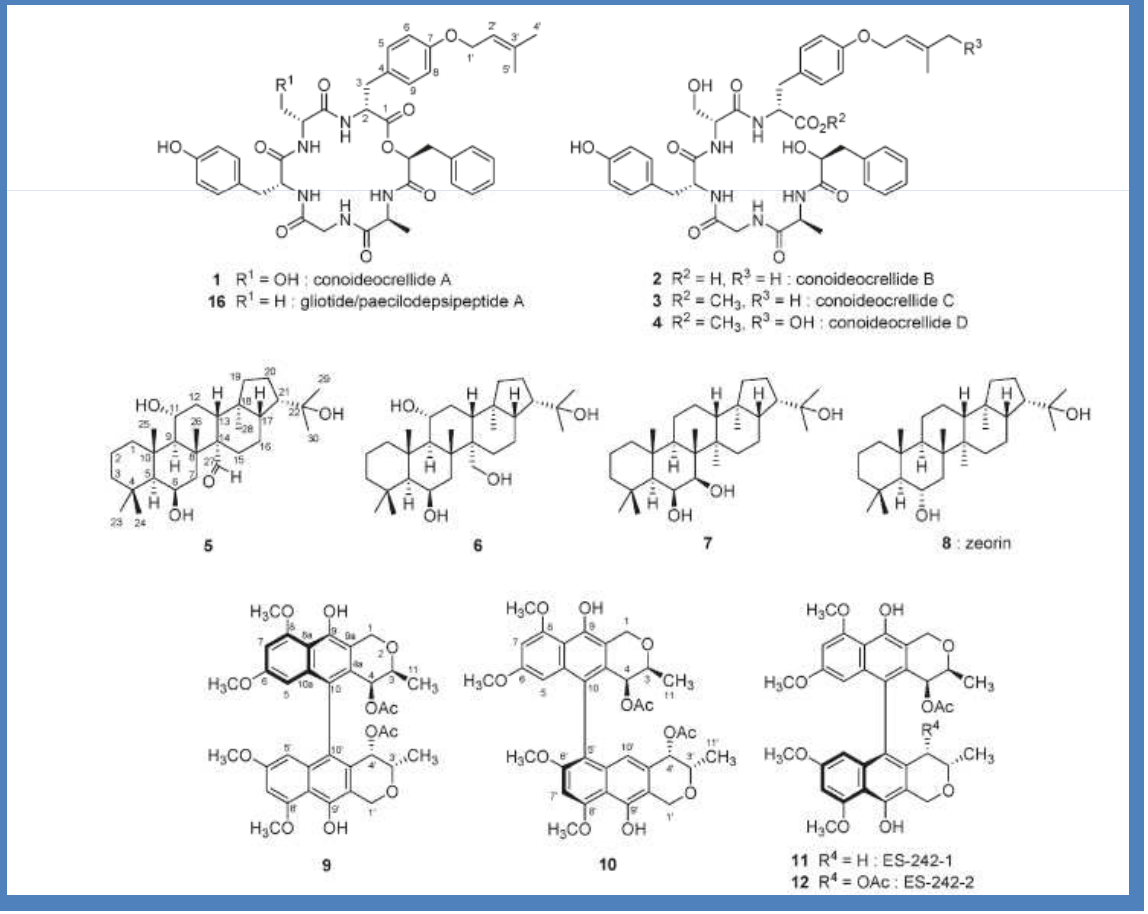
ARTICLE

pubs.acs.org/jnp

Bioactive Compounds from the Scale Insect Pathogenic Fungus *Conoideocrella tenuis* BCC 18627

Masahiko Isaka,* Somporn Palasarn, Sumalee Supothina, Somjit Komwijit, and J. Jennifer Luangsa-ard

National Center for Genetic Engineering and Biotechnology (BIOTEC), 113 Thailand Science Park, Phaholyothin Road, Klong Luang, Pathumthani 12120, Thailand



NRPS screening

Cordycipitaceae:

Beauveria bassiana
Cordyceps ninchukispora
Isaria tenuipes
Gibellula sp.




Clavicipitaceae:

Aschersonia samoensis
Metarhizium flavoviride
Hypocrella discoidea

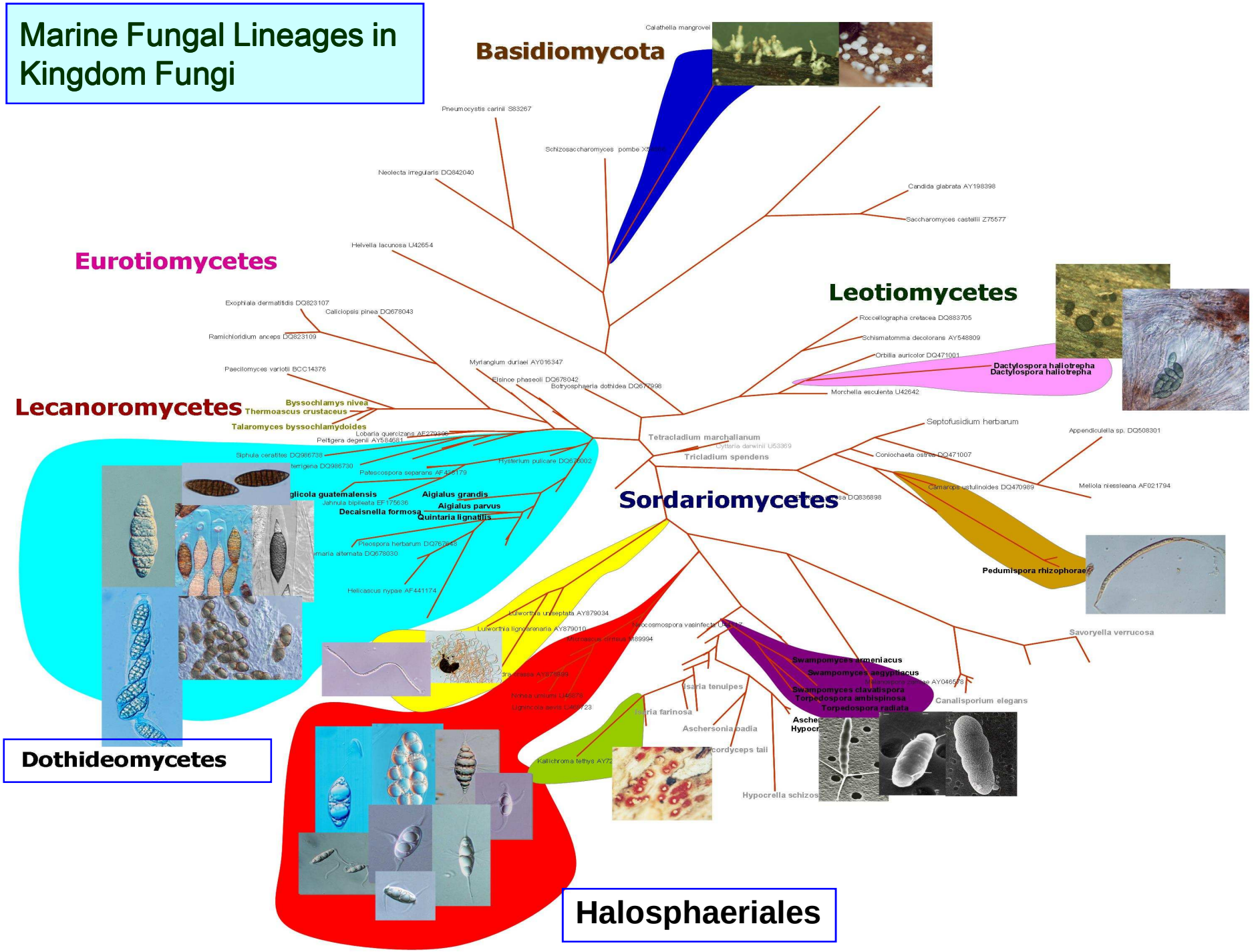


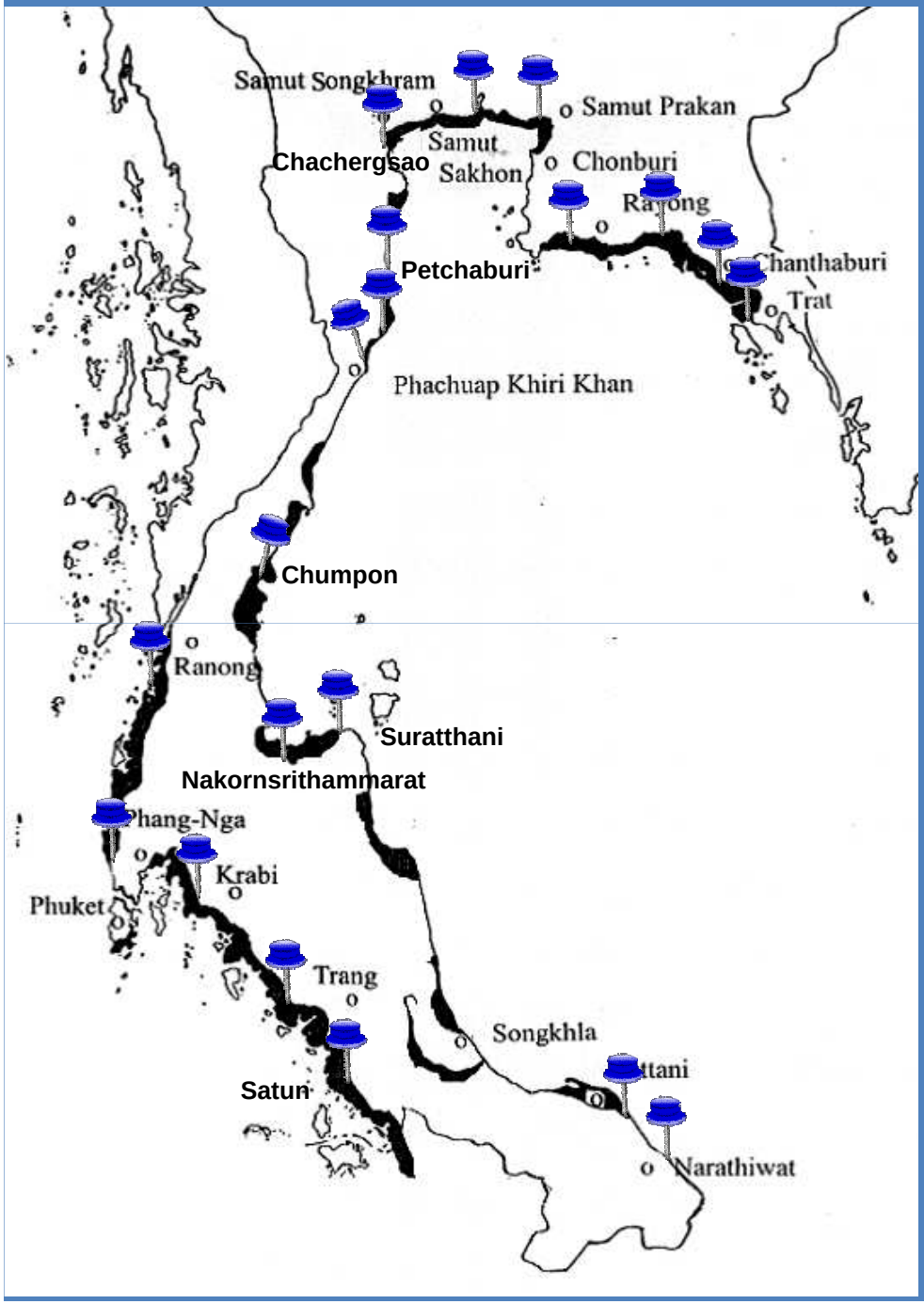
Marine Fungi

- Marine fungi are an ecological group that are able to grow and sporulate in marine habitats (Kohlmeyer & Kohlmeyer, 1979)
- Marine fungi grow on a variety of substrata.
- Marine fungi are mostly saprobes, and produce a wide range of enzymes. They play a major role in decaying woody materials in the marine habitats.



Marine Fungal Lineages in Kingdom Fungi





Thai marine fungal diversity

• Studies of marine fungi in Thailand have been restricted to sandy beaches, sea shores, mangroves and estuarine *Nypa* palm forests along Thai Gulf and Andaman sea.

•Marine and mangrove fungi documented for Thailand: total 163 (Jones *et al*. 2006, Sakayaroj et al 2011).

•A comprehensive classification of the filamentous marine fungi worldwide has outlined 530 sp .(from 321 genera) (Jones et al. 2009)

NEW RECORDS for Thailand

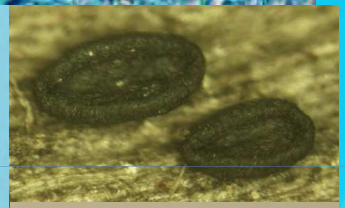
Lindra thalassiae

Swampomyces cf aegyptiacus

Manglicola guatemalensis

Lautospora simillima

Mauritiana rhizophorae



Patellaria atrata

Carinispora nypae

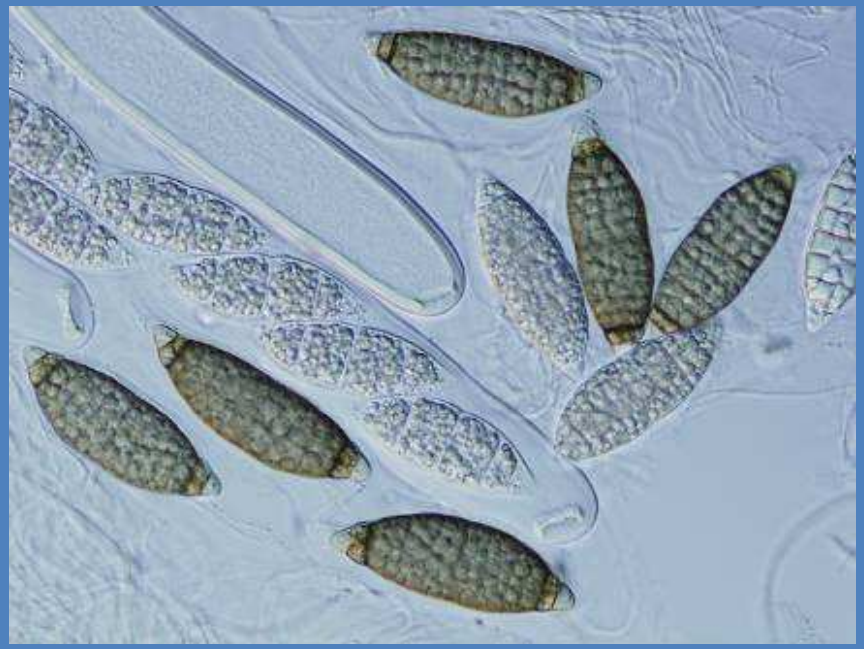
Aigialus rhizophorae

Aigialus mangrovei

Marine fungi as source of bioactive metabolites

- Marine fungi are of particular interest to the pharmaceutical industry
- The most successful marine fungi in producing new compounds are those isolated from mangrove habitats.
- They grow under extreme/stressful conditions and thus may produce a wider range of bioactive compounds.

Aigialus parvus BCC5311



Aigialomycins A and Hypothemycin showed significant antimalarial and antitumor properties

Isaka et al., 2002, J.Org. Chem. 67:1561-1566.
Isaka et al 2009, Tetrahedron 65 (2009) 4396–4403.
Vongvilai et al., 2009. J. Nat. Prod. 67: 457-460
Chinworrungsee, M., et. al. J. Chem. Soc., Perkin Trans. 2002; 2004

Halorosellinia oceanica BCC 5149

- **Produced halorosellins A and B,**

  4,8-dihydroxy- 6-methoxy-4,5-dimethyl-3-methyleneisochroman-1-one, 3-acetyl-7-hydroxy-5-methoxy-3,4-dimethyl-3*H*isobenzofuran-1-one and 17-dehydroxyhalorosellinic acid

- **Exhibited anti mycobacterial activity**

Thraustochytrids: A potential PUFA source

• Thraustochytrids are a group of nonphotosynthetic, heterotrophic marine organisms classified under the Labyrinthulomycetes , Kingdom Straminipila.

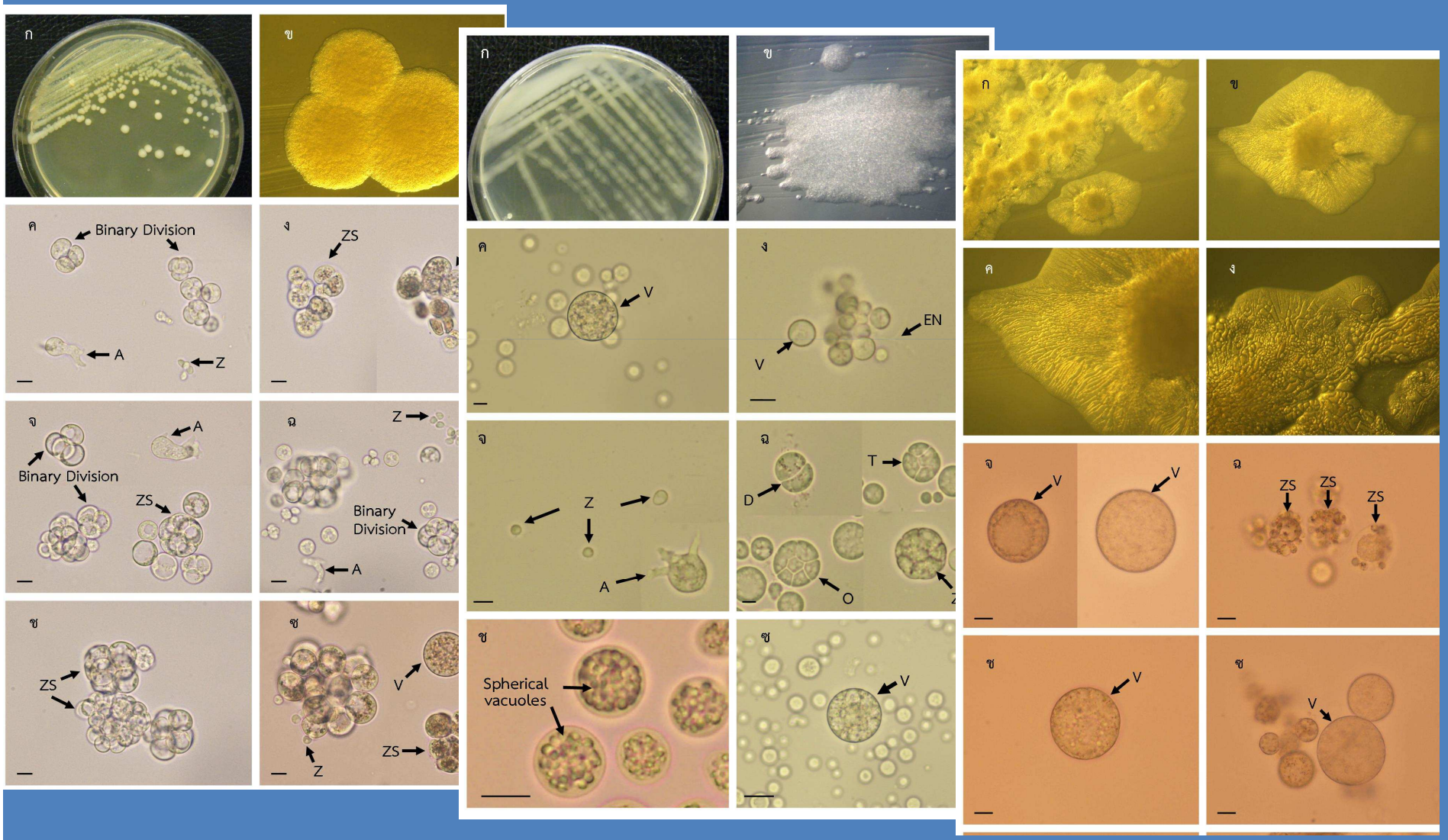
• Recently, attention has been given to this group of organisms because of their high lipid contents, particularly Poly Unsaturated Fatty Acids (PUFAs).

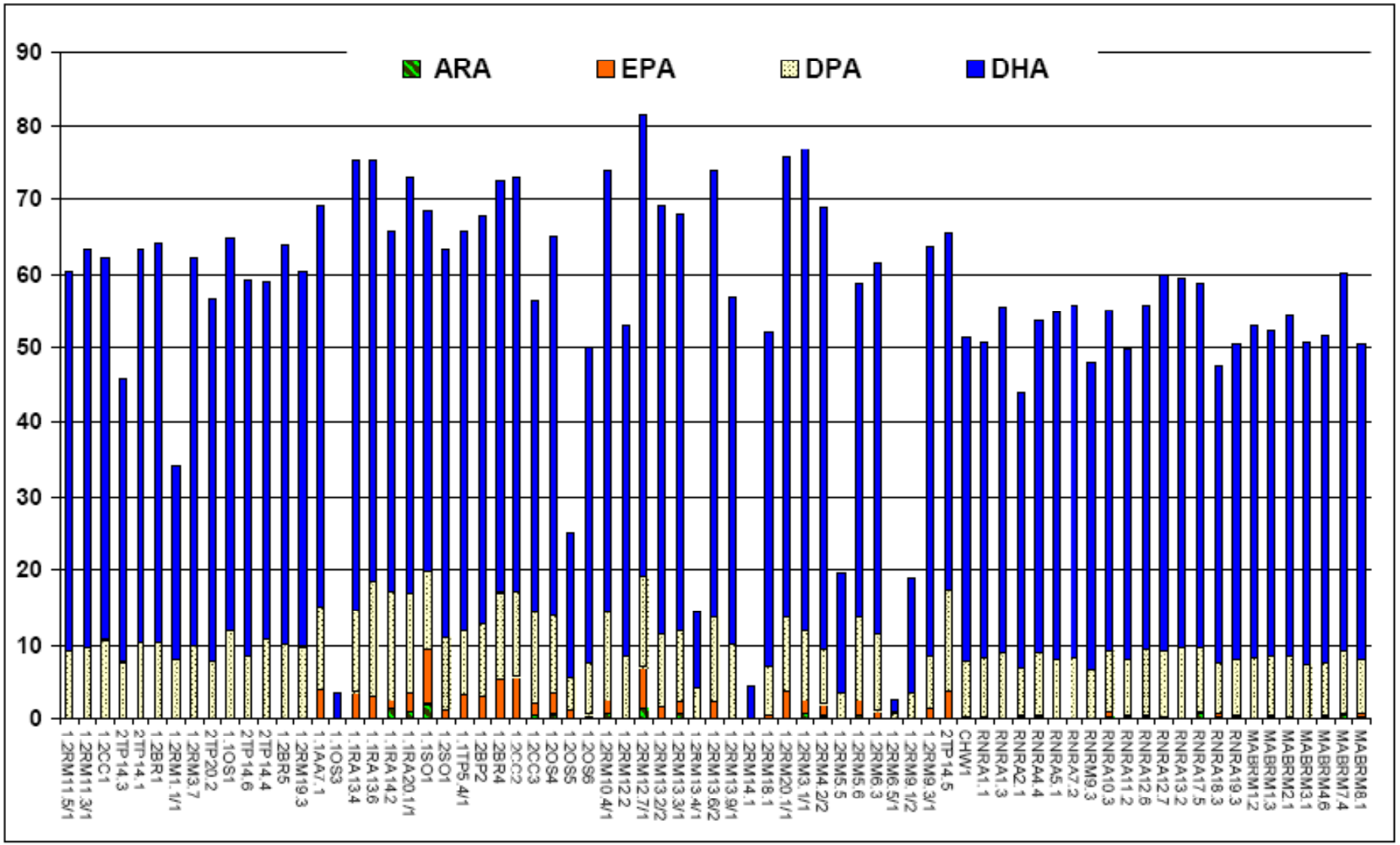
• With the continuously decreasing resources for traditional fish oils as PUFA sources for aquaculture, thraustochytrids offer a promising alternative and stable source for heterotrophic fatty acid production.

Marine and estuarine habitats: seawater, marine sediments, littoral algae, seaweeds, invertebrates, fallen mangrove leaves

Colony appearance, dividing cells, zoosporangium, zoospores and mature cells of thraustochytrids.

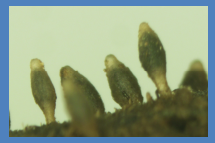
(The most common genera are *Aurantiochytrium* and *Schizochytrium.)*

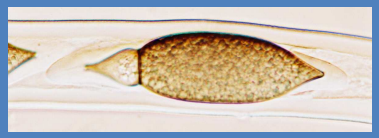



ARA
EPA
DPA
DHA
90
80
70
60
50
40
30
20
10
0
1.2RM11.5/1
1.2RM11.3/1
1.2CC1
2TP14.3
2TP14.1
1.2BR1
1.2RM1.1/1
1.2RM3.7
2TP20.2
1.1OS1
2TP14.6
2TP14.4
1.2BR5
1.2RM19.3
1.1AA7.1
1.1OS3
1.1RA13.4
1.1RA13.6
1.1RA14.2
1.1RA20.1/1
1.1SO1
1.2SO1
1.1TP5.4/1
1.2BP2
1.2BR4
1.2CC2
1.2CC3
1.2OS4
1.2OS5
1.2OS6
1.2RM10.4/1
1.2RM12.2
1.2RM12.7/1
1.2RM13.2/2
1.2RM13.3/1
1.2RM13.4/1
1.2RM13.6/2
1.2RM13.9/1
1.2RM14.1
1.2RM18.1
1.2RM20.1/1
1.2RM3.1/1
1.2RM4.2/2
1.2RM5.5
1.2RM5.6
1.2RM6.3
1.2RM6.5/1
1.2RM9.1/2
1.2RM9.3/1
2TP14.5
CHW1
RNRA1.1
RNRA1.3
RNRA2.1
RNRA4.4
RNRA5.1
RNRA7.2
RNRM9.3
RNRA10.3
RNRA11.2
RNRA12.6
RNRA12.7
RNRA13.2
RNRA17.5
RNRA18.3
RNRA19.3
MABRM1.2
MABRM1.3
MABRM2.1
MABRM3.1
MABRM4.6
MABRM7.4
MABRM8.1

Marine Dothideomycetes

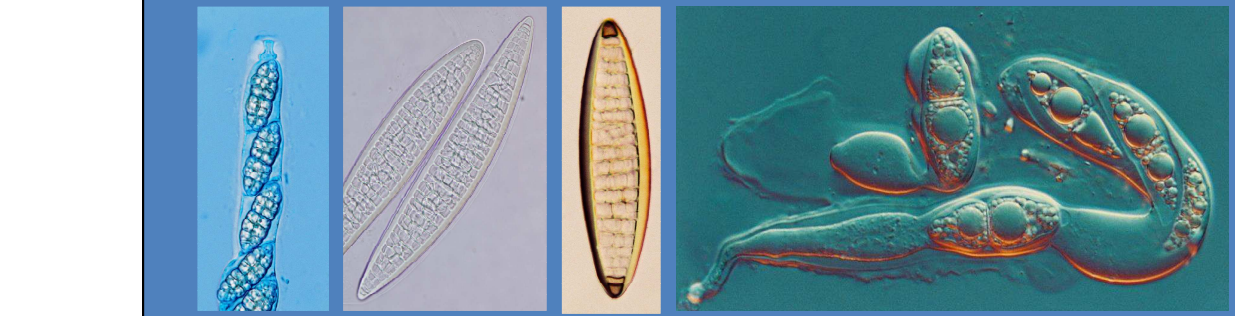
Nypa fruticans

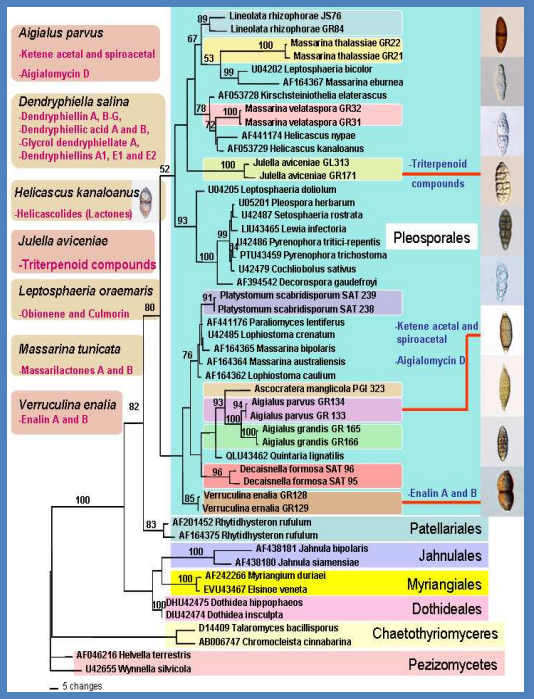


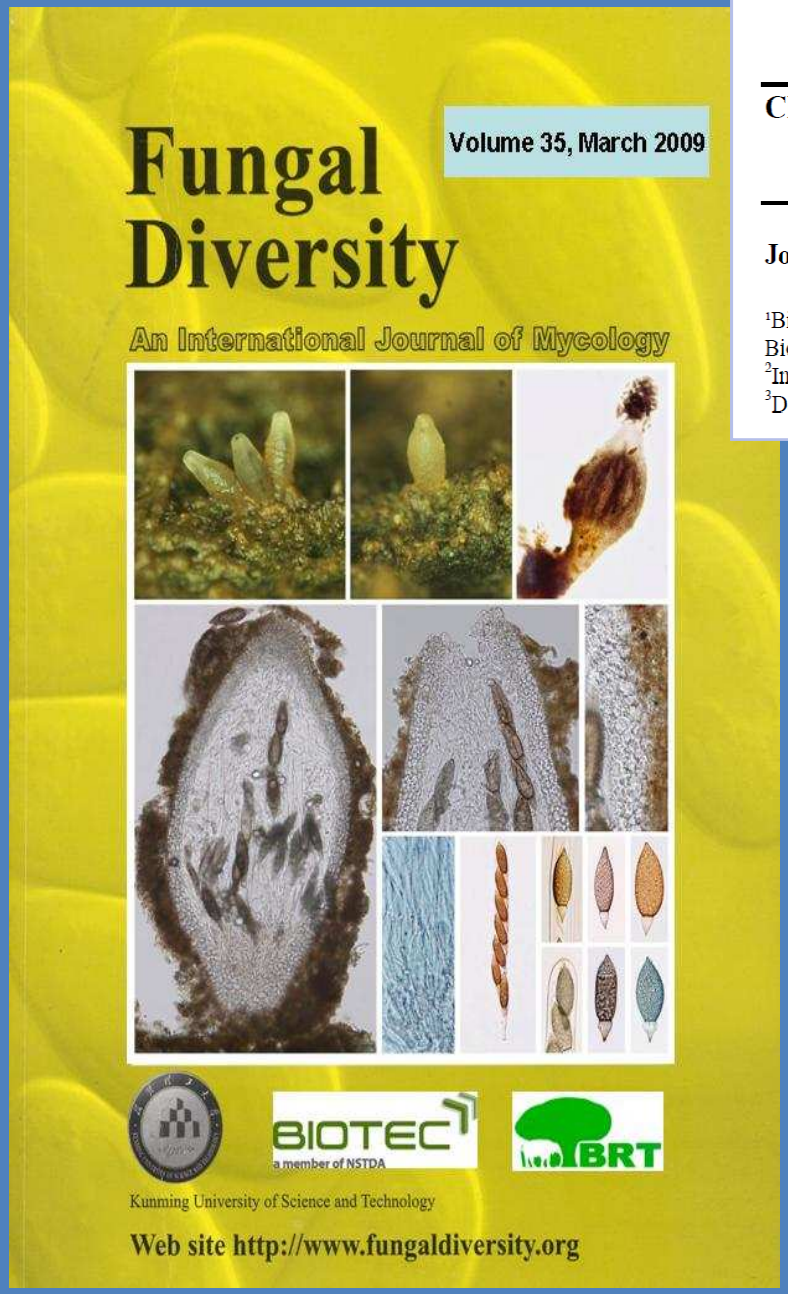


Mangrove wood

Rhizomes of Sea grasses





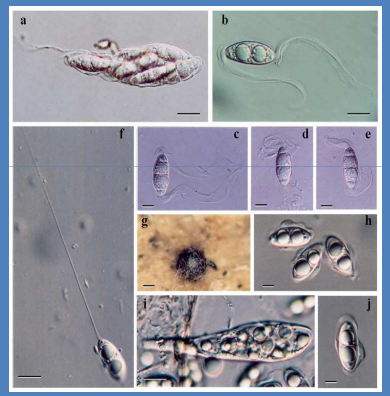


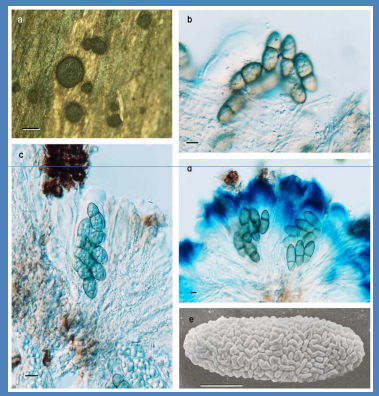
Fungal Diversity

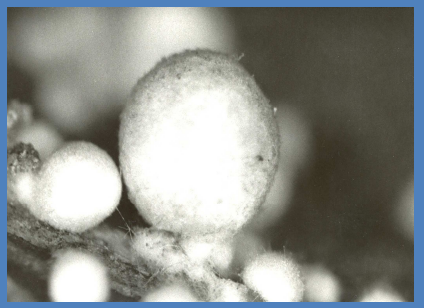
Classification of marine Ascomycota, anamorphic taxa and Basidiomycota

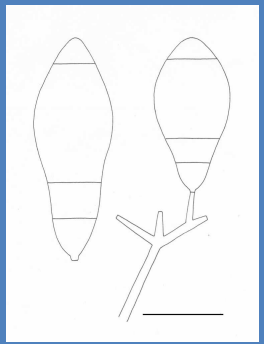
Jones, E.B.G.[1*], Sakayaroj, J.[1], Suetrong, S.[1, 3], Somrithipol, S.[1] and Pang, K.L.[2]

[1]Bioresources Technology Unit, Phylogenetics Laboratory, National Center for Genetic Engineering and Biotechnology, 113 Paholyothin Road, Khlong 1, Khlong Luang, Pathum Thani 12120, Thailand
[2]Institute of Marine Biology, National Taiwan Ocean University, No. 2 Pei-Ning Road, Keelung 20224, Taiwan
[3]Department of Microbiology, Faculty of Science, Prince of Songkla University, Hat Yai, Songkhla, 90112, Thailand.







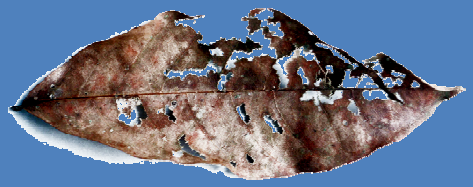


Examples of bioactive compounds from Thai marine fungi

Species	Activity	Chemical structure	References
Aigialus parvus 	Anti-malarial	Aigialomycin D, Aigialone and aigialospirol	Isaka et al 2002; Vongvilai et al 2004
Halorosellinia oceanica	Weak anti-mycobacterial	Halorosellinic acid	Chinworrungsee et al, 2001
Halorosellinia oceanica 	Mild anti-mycobacterial	Halorosellins A, B	Chinworrungsee et al, 2004

FUNGI ON DECAYING SEEDS AND LEAF LITTER

Highlight



Leaf litter fungi
(Twelve new described species)

- ***Berkleasmium typhae***
- ***Calcarisporium phaeopodium***
- ***Dictyoarthrinium synnematicum***
- ***Digitoramispora lageniformis***
- ***Falcocladium turbinatum***
- ***Infundibulomyces cupulata***
- ***Infundibulomyces oblongisporus***
- ***Lauriomyces cylindricus***
- ***Lauriomyces ellipticus***
- ***Melanogrophium proliferum***
- ***Pseudoacrodictys dimorphospora***
- ***Pseudorobillarda siamensis***

One fungus produces a new bioactive compound.

- ***Kionochaeta ramifera***
  → Ramiferin A

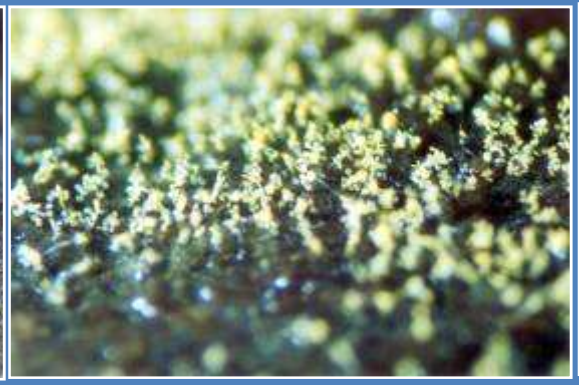
Fungi on decaying seed
(Two new described species)

- ***Cirrenalia nigrospora***
- ***Lauriomyces sakaeratensis***

Two fungi produce 2 new bioactive compounds.

- ***Kionochaeta pughii***
  → Pughiinin A
- ***Menisporopsis theobromae***
  → Menisporopsin A

Fungal characteristics under dissection microscope



Common species on decaying fruits and seeds

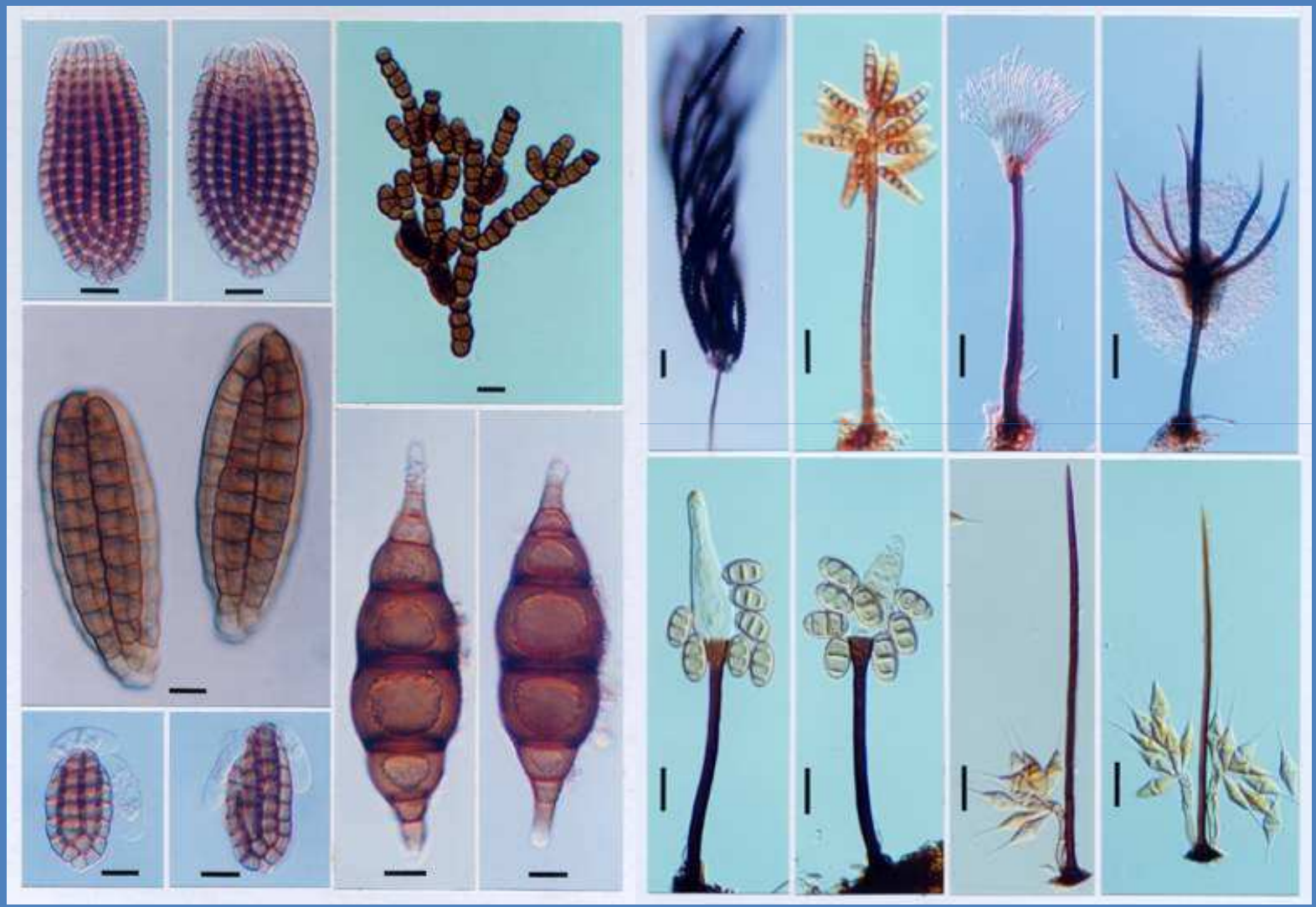
Dictyochaeta sp.

Thozetella nivea

Cryptophialoidea secunda

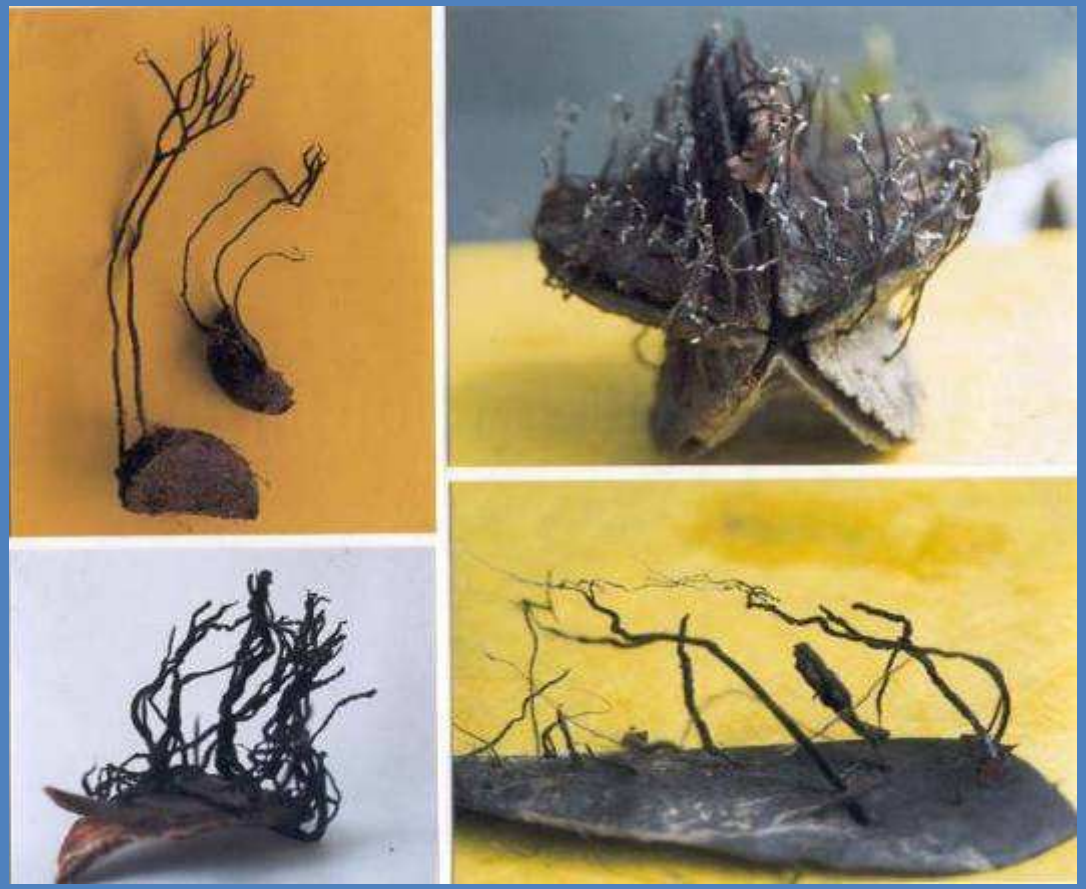
Dinemasporium lanatum

Anamorphic fungi on decaying fruits and seeds



Somrithipol, S., Hywel-Jones, N.L. and Jones, E.B.G., and 2004. Seed fungi. In Thai Fungal Diversity. (E.B.G Jones, M. Tanticharoen and K.D. Hyde, eds.). BIOTEC, Thailand. pp. 129-140.

Teleomorphic fungi on decaying fruits and seeds

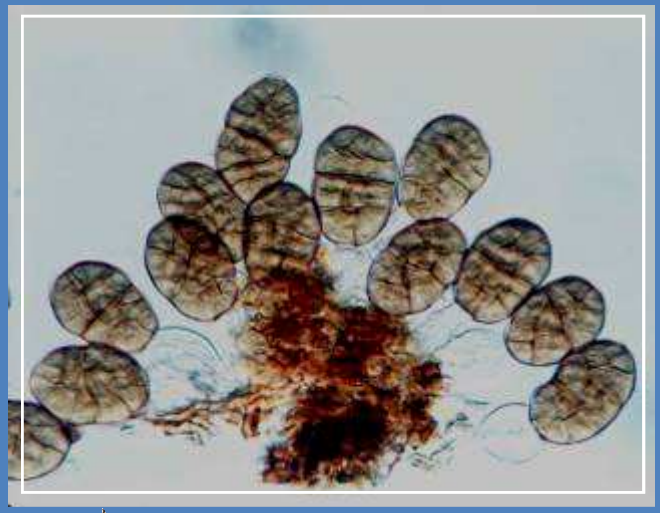


Xylaria species
ASCOMYCETES

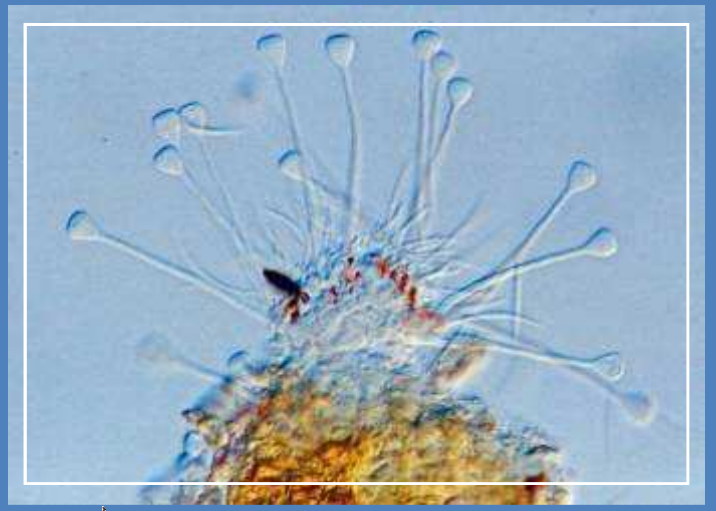
Coprinus species
BASIDIOMYCETES

Some new fungi on seed and leaf litter

Cirrenalia nigrospora



Berkleasmium typhae



Falcocladium turbinatum

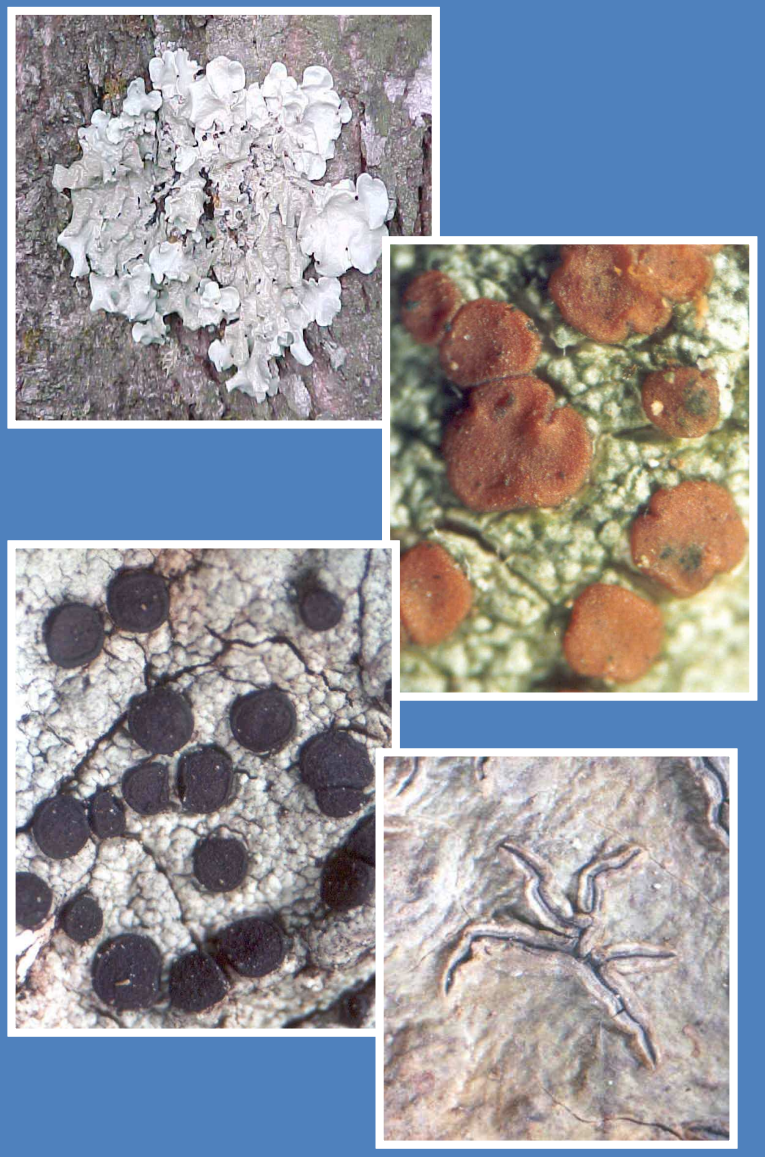
Lauriomyces sakaeratensis

Lauriomyces cylindricus

Lauriomyces ellipticus

Melanographium proliferum

Lichens



Lichen herbarium

3,515 specimens comprising

3 orders

14 families

33 genera and ~ 250 species

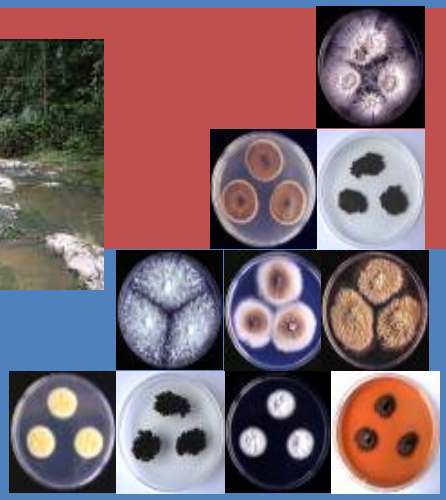
Lichenized fungi

- 152 strains

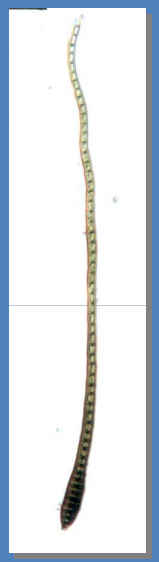
- 36 strains showed the bioactive screening against anti-*Candida albicans* (30%), anti-*Herpes simplex* virus (50%), anti-tuberculosis (25-50 µg/ml), anti-cancer (5%) and anti-malaria at ED_{50} = 0.84-12.68 µg/ml

- 2 new compounds were found

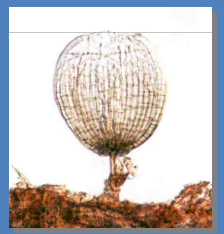
Freshwater fungi



Lignicolous Freshwater fungi



Aquatic & aero-aquatic fungi



Groups encountered :~4500 specimens
- Ascomycota : >400 spp.
- Basidiomycota : ~ 15 spp.
- Mitosporic (excluding Ingoldian fungi) : >300 spp.
- Aquatic & aero-aquatic fungi : ~ 200-300 spp.

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Identification of Xylariaceae by inducing the formation of fruiting bodies

Palm Fungi

Selected palms to study

1. *Licuala longicalycata*
2. *Nenga pumila*
3. *Eleiodoxa conferta*

Peat swamp palms

4. *Metroxylon sagu*
5. *Calamus spp.*
6. *Arenga sp.*
7. *Elaeis guineensis*

Terrestrial palms

Results

Saprophytes

- Ascomycetes 251 taxa
- Basidiomycetes 298 collections
- Anamorphic fungi 293 taxa

Endophytes

- 717 morpho types (4 different trips)

New Taxa

- 18 new species were described including 13 genera (5 new genera, 13 new species)
- 15 new species await descriptions

Potential application of fungal isolates from palms

- Weight loss from basidiomycetes
- Antagonistic fungi from palms
- Edible mushroom cultivation from oil palm waste

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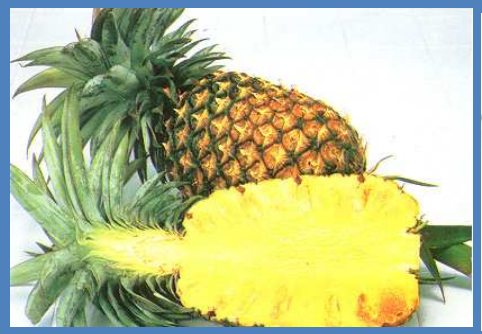
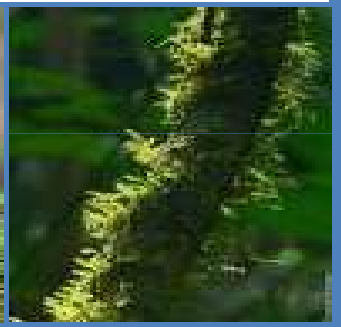
Sources of yeasts



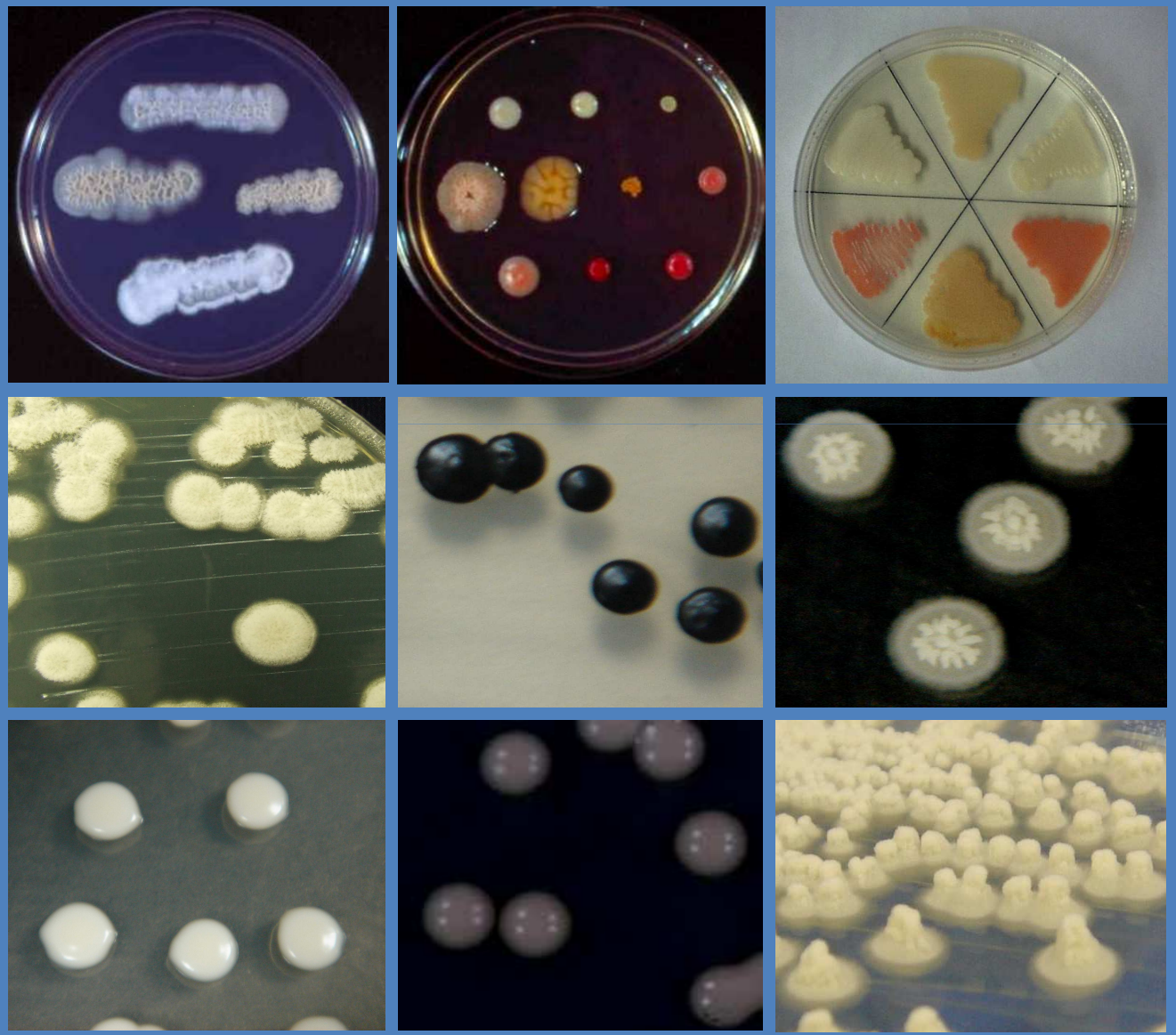




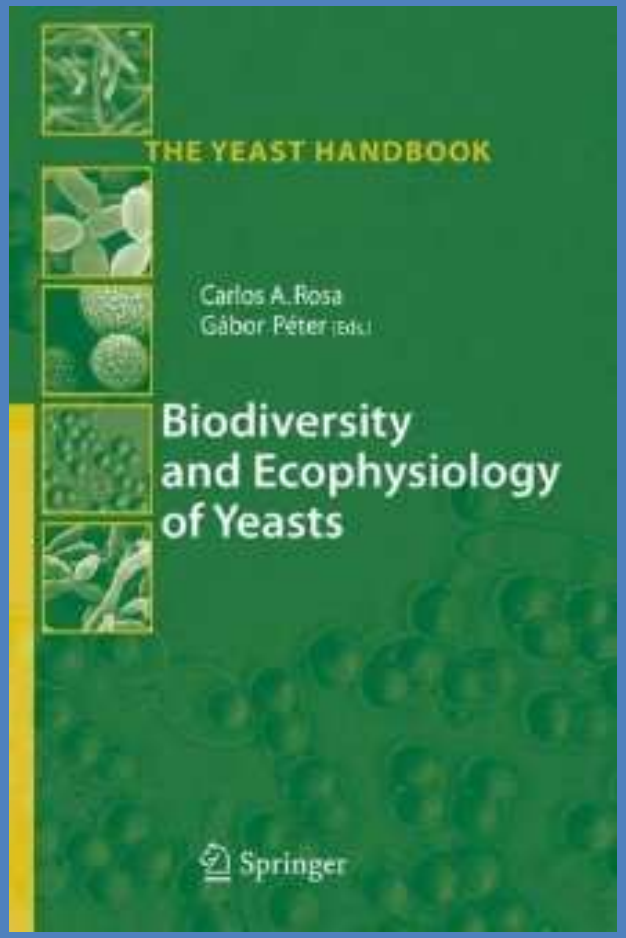




Yeasts colony



Biodiversity of Yeasts in Thailand and Asia



Yeast biodiversity in tropical forest of Asia

by T. Nakase and S. Jindamorakot published in

The Yeast Handbook "Biodiversity and Ecophysiology of Yeasts"

Edited by Carlos A. Rosa and Gábor Péter
Springer January 2006

http://www.cplbookshop.com/contents/C2426.htm

New Yeast Species Found in Thailand

Thailand have long been considered to be rich in microbial biodiversity. Since the first report describing new yeast species, *Kockovaella thailandica* and *K. imperatae* from Thailand (Nakase et al., 1991), the describing new yeast taxa have been increased year and year and 59 new yeast species from Thailand are currently recognized, 34 ascomycetous yeasts and 25 of basidiomycetous yeasts. These studies suggested that a vast number of unknown yeast species are living in the natural environment of Thailand.

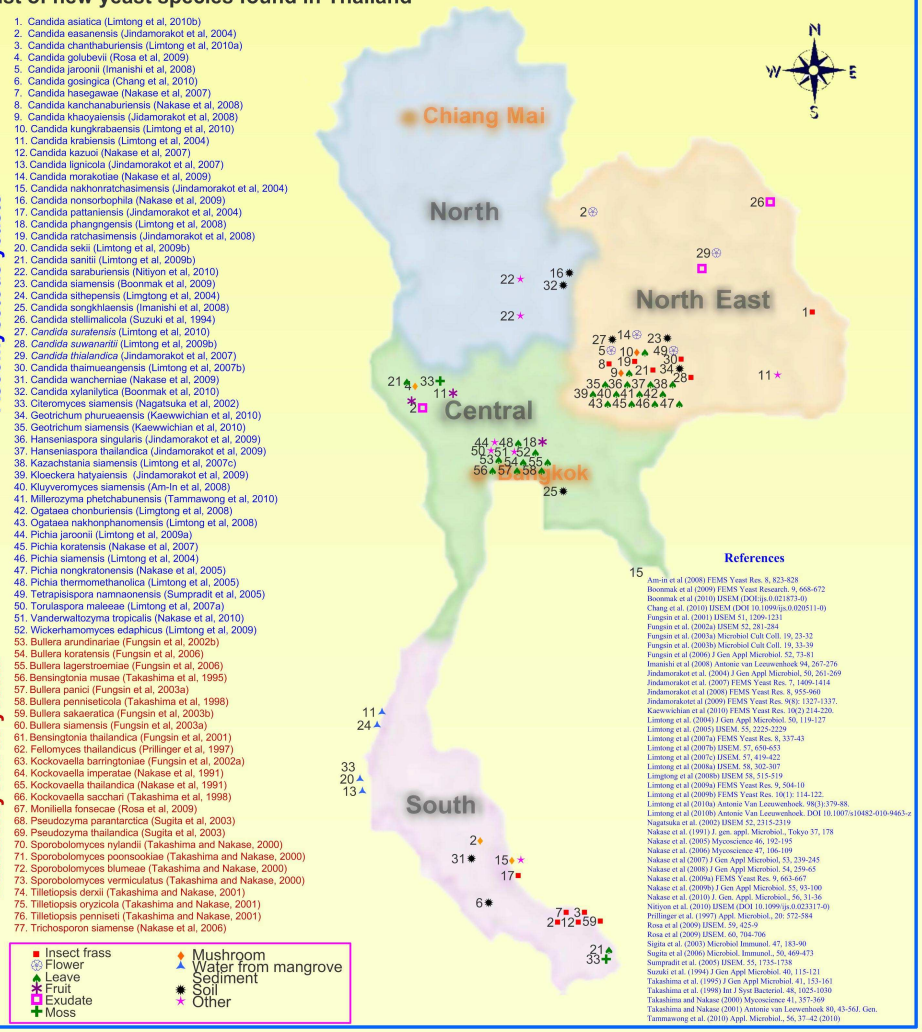
List of new yeast species found in Thailand

Ascomycetous yeasts

1. Candida asiatica (Limtong et al, 2010b)
2. Candida easanensis (Jindamorakot et al, 2004)
3. Candida chanthaburiensis (Limtong et al, 2010a)
4. Candida golubevii (Rosa et al, 2009)
5. Candida jaroonii (Imanishi et al, 2008)
6. Candida gosingica (Chang et al, 2010)
7. Candida hasegawae (Nakase et al, 2007)
8. Candida kanchanaburiensis (Nakase et al, 2008)
9. Candida khaoyaiensis (Jidamorakot et al, 2008)
10. Candida kungkrabaensis (Limtong et al, 2010)
11. Candida krabiensis (Limtong et al, 2004)
12. Candida kazuoi (Nakase et al, 2007)
13. Candida lignicola (Jindamorakot et al, 2007)
14. Candida morakotiae (Nakase et al, 2009)
15. Candida nakhonratchasimensis (Jindamorakot et al, 2004)
16. Candida nonsorbophila (Nakase et al, 2009)
17. Candida pattaniensis (Jindamorakot et al, 2004)
18. Candida phangngensis (Limtong et al, 2008)
19. Candida ratchasimensis (Jindamorakot et al, 2008)
20. Candida sekii (Limtong et al, 2009b)
21. Candida santiii (Limtong et al, 2009b)
22. Candida saraburiensis (Nitiyon et al, 2010)
23. Candida siamensis (Boonmak et al, 2009)
24. Candida sithepensis (Limgtong et al, 2004)
25. Candida songkhlaensis (Imanishi et al, 2008)
26. Candida stellimalicola (Suzuki et al, 1994)
27. *Candida suratensis* (Limtong et al, 2010)
28. *Candida suwanaritii* (Limtong et al, 2009b)
29. *Candida thialandica* (Jindamorakot et al, 2007)
30. Candida thaimueangensis (Limtong et al, 2007b)
31. Candida wancherniae (Nakase et al, 2009)
32. Candida xylanilytica (Boonmak et al, 2010)
33. Citeromyces siamensis (Nagatsuka et al, 2002)
34. Geotrichum phurueaensis (Kaewwichian et al, 2010)
35. Geotrichum siamensis (Kaewwichian et al, 2010)
36. Hanseniaspora singularis (Jindamorakot et al, 2009)
37. Hanseniaspora thailandica (Jindamorakot et al, 2009)
38. Kazachstania siamensis (Limtong et al, 2007c)
39. Kloeckera hatyaiensis (Jindamorakot et al, 2009)
40. Kluyveromyces siamensis (Am-In et al, 2008)
41. Millerozyma phetchabunensis (Tammawong et al, 2010)
42. Ogataea chonburiensis (Limgtong et al, 2008)
43. Ogataea nakhonphanomensis (Limtong et al, 2008)
44. Pichia jaroonii (Limtong et al, 2009a)
45. Pichia koratensis (Nakase et al, 2007)
46. Pichia siamensis (Limtong et al, 2004)
47. Pichia nongkratonensis (Nakase et al, 2005)
48. Pichia thermomethanolica (Limtong et al, 2005)
49. Tetrapisispora namnaonensis (Sumpradit et al, 2005)
50. Torulaspora maleeae (Limtong et al, 2007a)
51. Vanderwaltozyma tropicalis (Nakase et al, 2010)
52. Wickerhamomyces edaphicus (Limtong et al, 2009)

Basidiomycetous yeasts

53. Bullera arundinariae (Fungsin et al, 2002b)
54. Bullera koratensis (Fungsin et al, 2006)
55. Bullera lagerstroemiae (Fungsin et al, 2006)
56. Bensingtonia musae (Takashima et al, 1995)
57. Bullera panici (Fungsin et al, 2003a)
58. Bullera penniseticola (Takashima et al, 1998)
59. Bullera sakaeratica (Fungsin et al, 2003b)
60. Bullera siamensis (Fungsin et al, 2003a)
61. Bensingtonia thailandica (Fungsin et al, 2001)
62. Fellomyces thailandicus (Prillinger et al, 1997)
63. Kockovaella barringtoniae (Fungsin et al, 2002a)
64. Kockovaella imperatae (Nakase et al, 1991)
65. Kockovaella thailandica (Nakase et al, 1991)
66. Kockovaella sacchari (Takashima et al, 1998)
67. Moniliella fonsecae (Rosa et al, 2009)
68. Pseudozyma parantarctica (Sugita et al, 2003)
69. Pseudozyma thailandica (Sugita et al, 2003)
70. Sporobolomyces nylandii (Takashima and Nakase, 2000)
71. Sporobolomyces poonsookiae (Takashima and Nakase, 2000)
72. Sporobolomyces blumeae (Takashima and Nakase, 2000)
73. Sporobolomyces vermiculatus (Takashima and Nakase, 2000)
74. Tilletiopsis derxii (Takashima and Nakase, 2001)
75. Tilletiopsis oryzicola (Takashima and Nakase, 2001)
76. Tilletiopsis penniseti (Takashima and Nakase, 2001)
77. Trichosporon siamense (Nakase et al, 2006)



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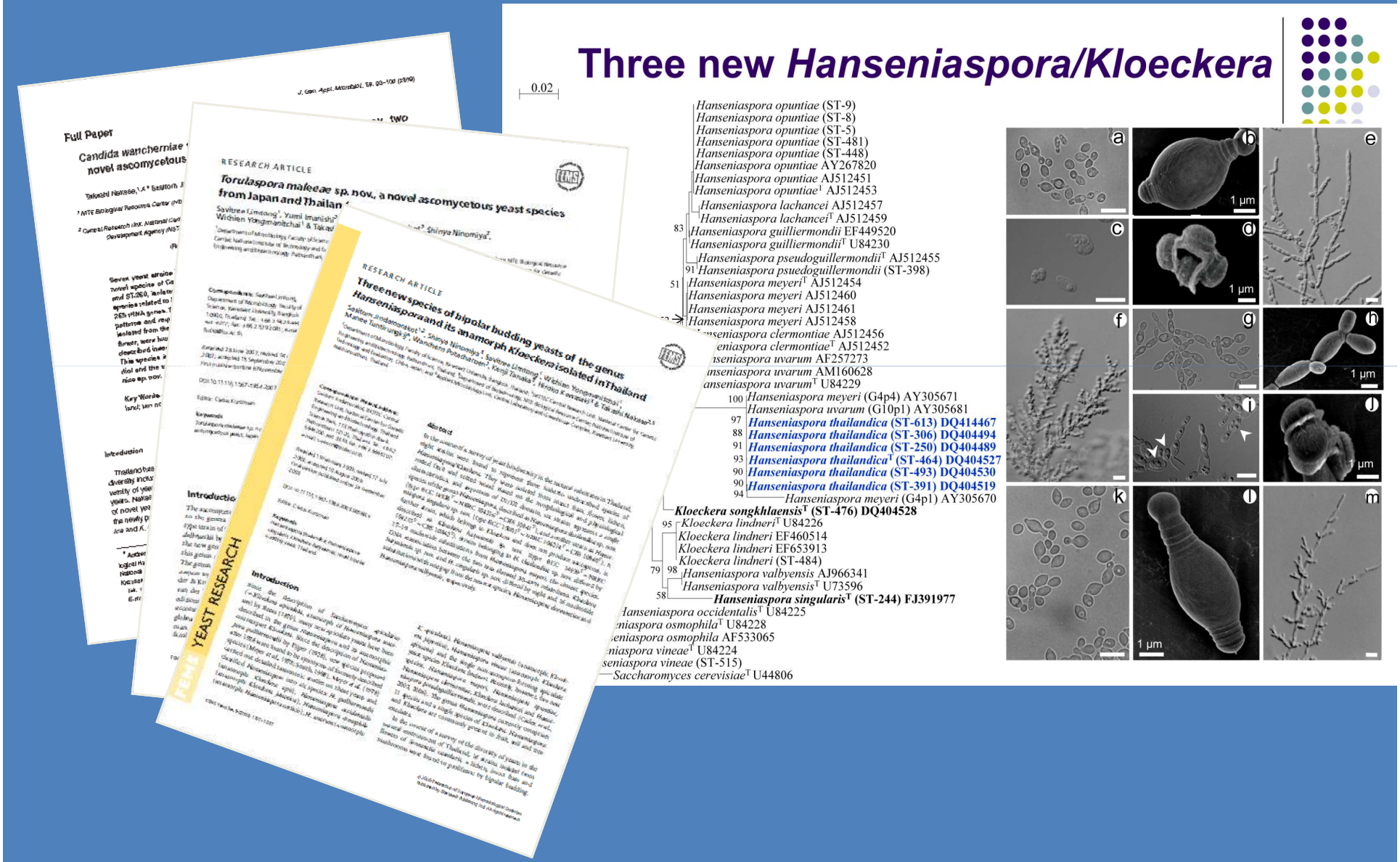
Diversity of yeasts in Thailand

Many new species of yeasts have been isolated from Thailand and described in recent years.

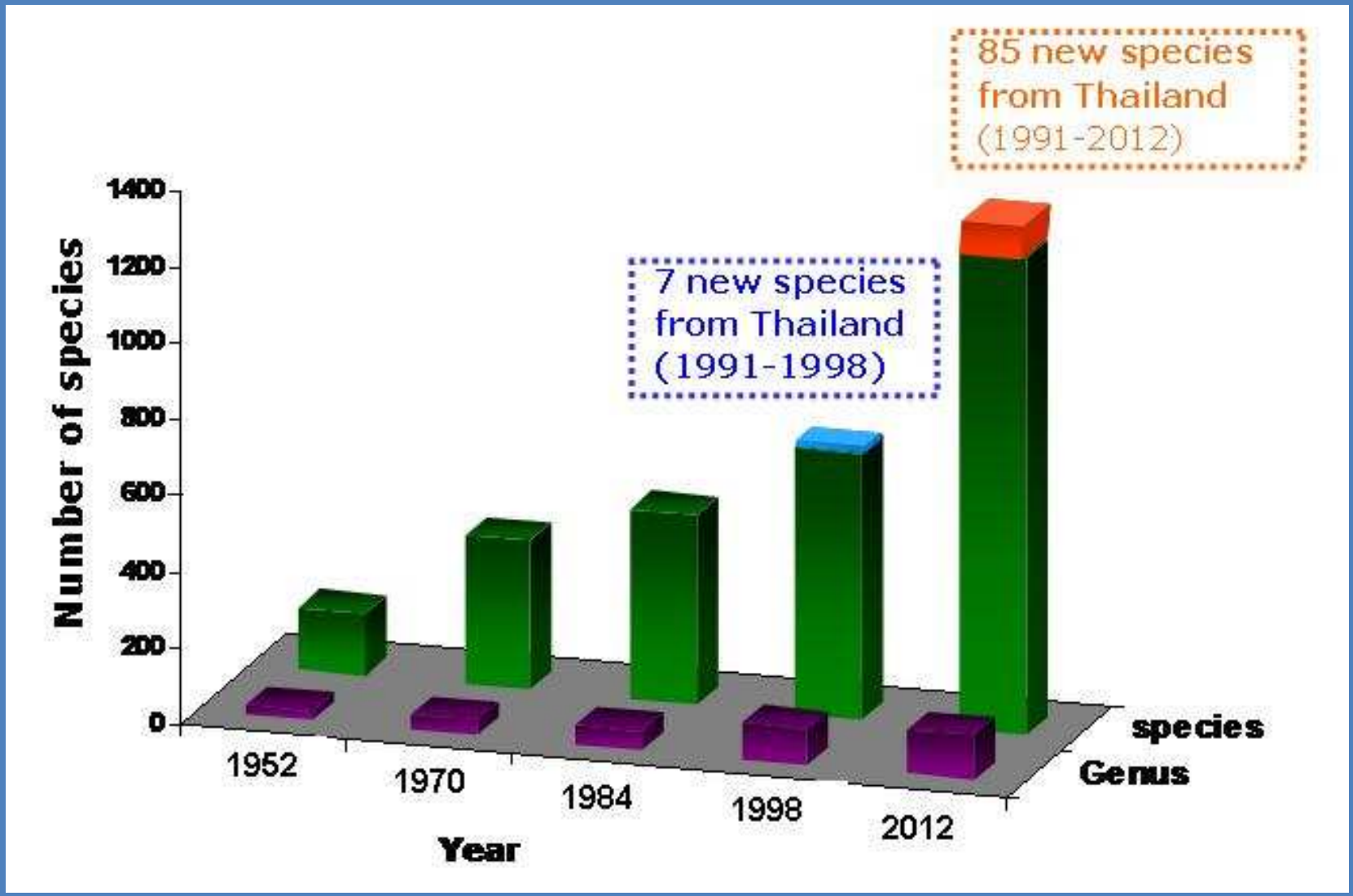
More than 80 species of ascomycetous yeasts have been described as new species from various kinds of substrates in Thailand from 1991-2012.

Many new yeast species published from Thailand



The increasing number of recognized species

(The Yeast, A Taxonomic study 5th edition)



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Dr. Satinee Suetrong

BIOTEC Culture Collection

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Ms. Suwanee Chunhametha
Mr. Sarawut Saidaengkham

Thank you for your attention