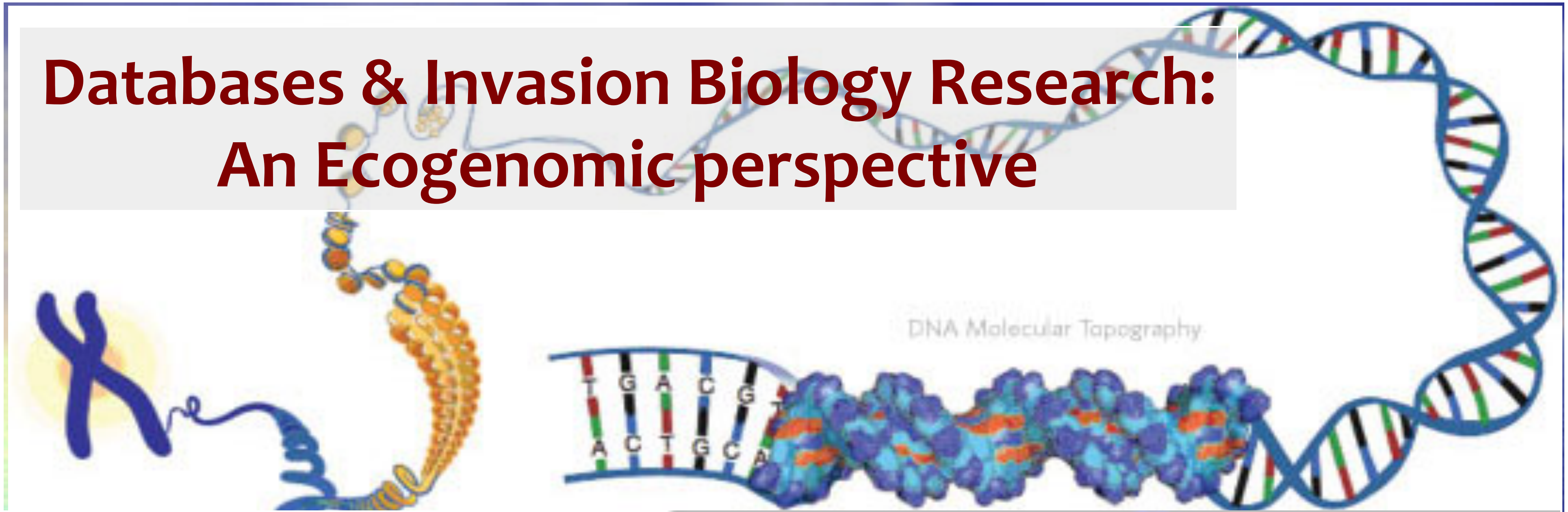
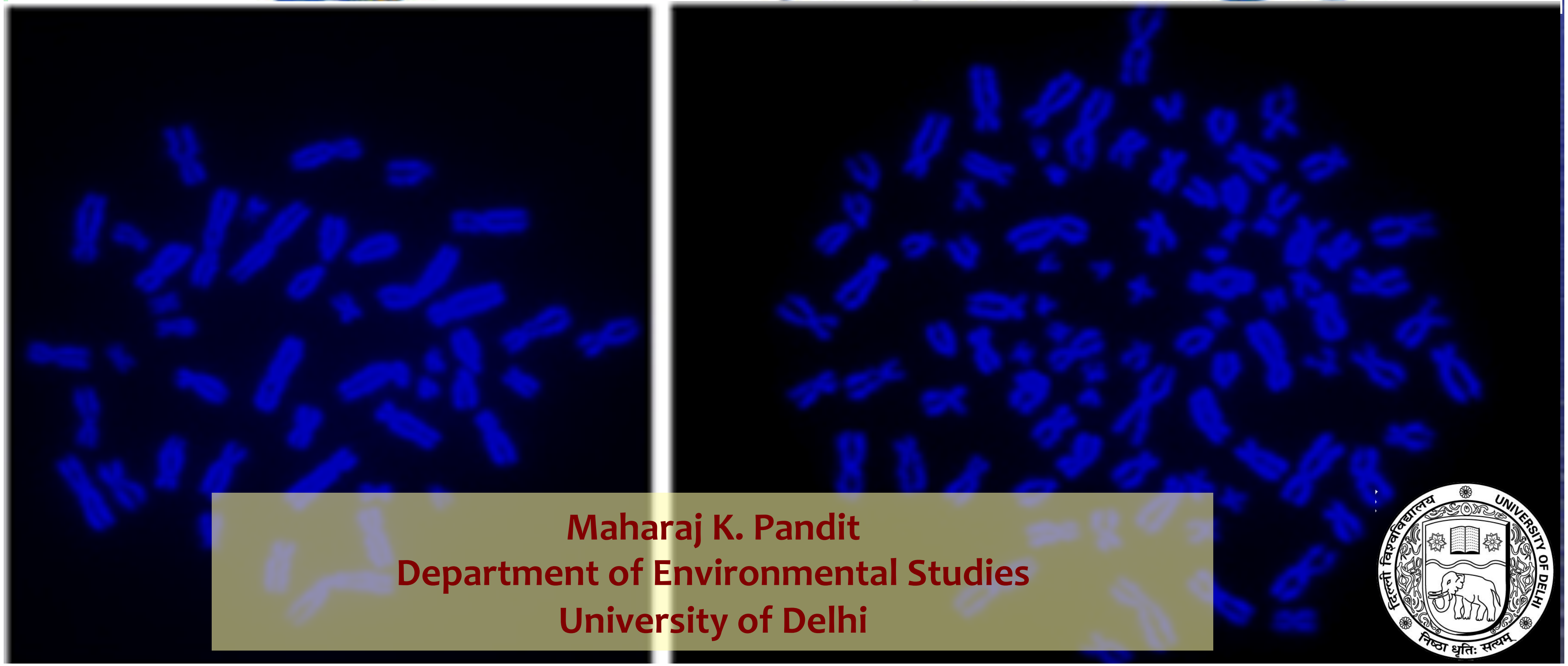
Databases & Invasion Biology Research: An Ecogenomic perspective



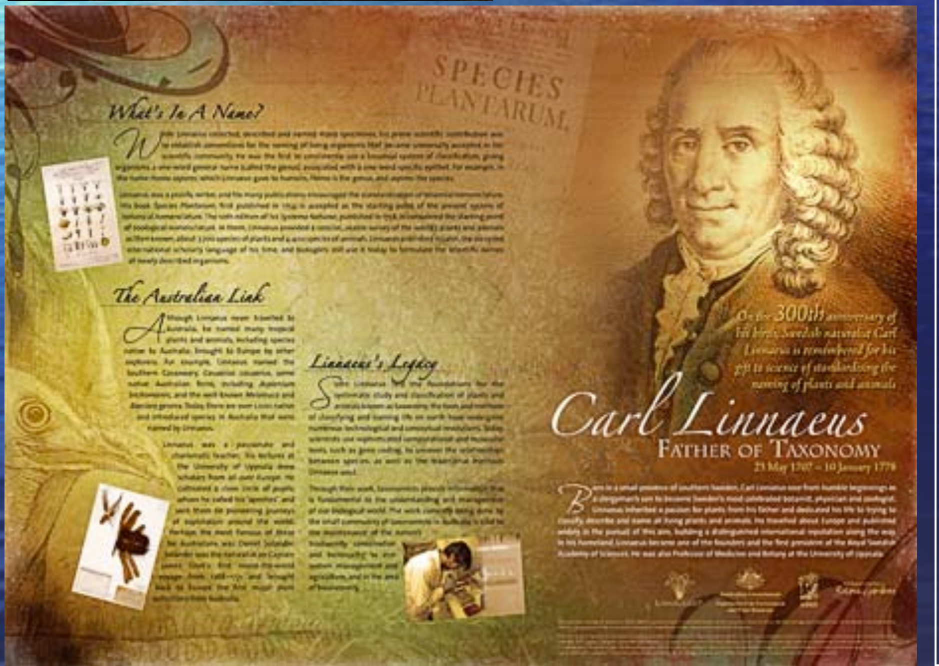


Maharaj K. Pandit
Department of Environmental Studies
University of Delhi

The Outline

- Why database?
- I had a Question for myself?
- Phylogenetic and Ecological
- The present approach
- The genetic & genomic traits
- Results – General Theory
- Databases – Research & Policy

First Bioinformatics Crisis!



"Taxonomy, the classification of living things, has its origins in ancient Greece and in its modern form dates back nearly 250 years, to when Linnaeus [1707 – 1778] introduced the binomial classification still used today. Linnaeus, of course, hugely underestimated the number of plants and animals on Earth. As subsequent workers began to describe more and more species, often in ignorance of each others' work, the resulting confusion and chaos threatened to destroy the whole enterprise while still in its infancy. In today's jargon, we might call this the first bioinformatics crisis."

H. Charles J. Godfray, 2002

Second Bioinformatics Crisis!

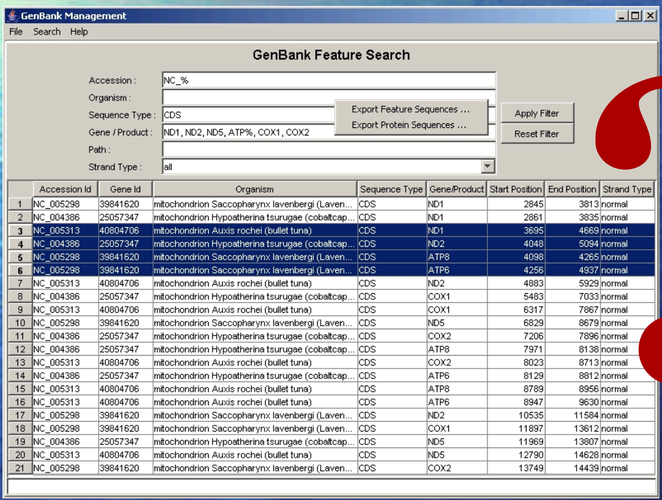
commentary

Challenges for taxonomy

The discipline will have to reinvent itself if it is to survive and flourish.

H. Charles J. Godfray

NATURE | VOL 417 | 2 MAY 2002 | www.nature.com



GenBank Management

File Search Help

GenBank Feature Search

Accession : NC_%

Organism :

Sequence Type : CDS

Gene / Product : ND1, ND2, ND5, ATP%, COX1, COX2

Path :

Strand Type : all

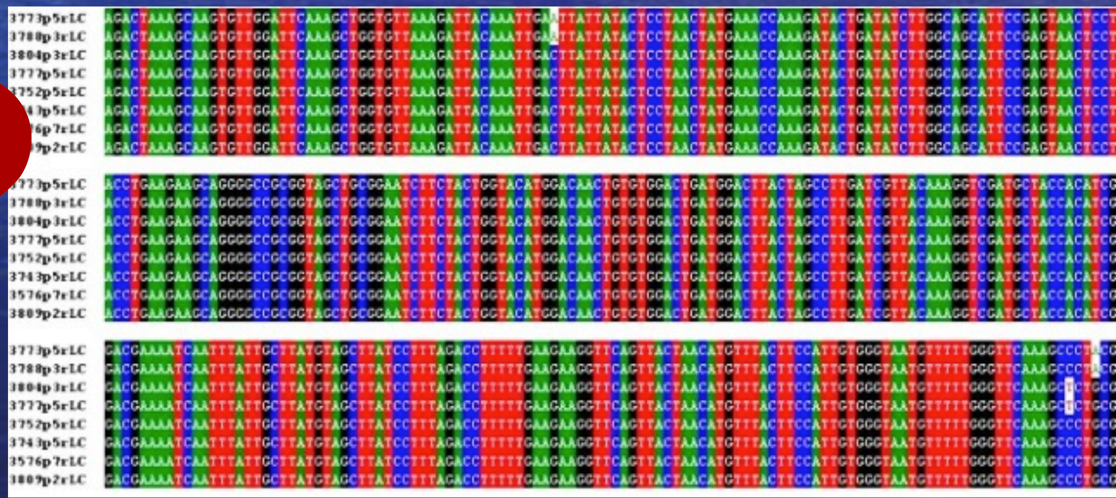
Export Feature Sequences ...

Export Protein Sequences ...

Apply Filter

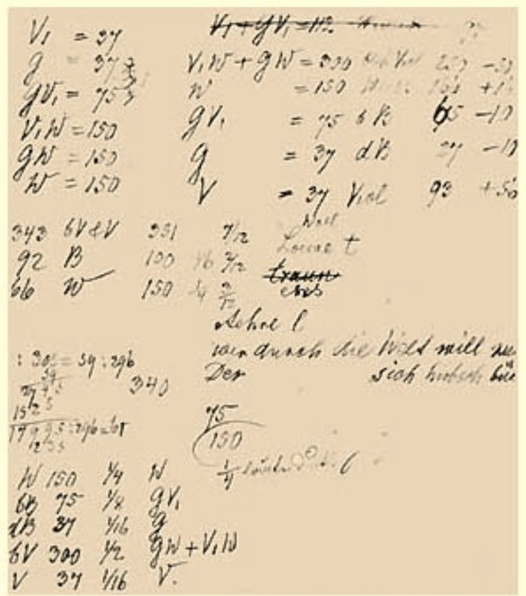
Reset Filter

	Accession Id	Gene Id	Organism	Sequence Type	Gene/Product	Start Position	End Position	Strand Type
1	NC_005298	39841620	mitochondrion Saccopharynx lavenbergi (Laven...	CDS	ND1	2845	3813	normal
2	NC_004386	25057347	mitochondrion Hypoatherina tsurugae (cobaltcap...	CDS	ND1	2861	3835	normal
3	NC_005313	40804706	mitochondrion Auxis rochei (bullet tuna)	CDS	ND1	3695	4669	normal
4	NC_004386	25057347	mitochondrion Hypoatherina tsurugae (cobaltcap...	CDS	ND2	4048	5094	normal
5	NC_005298	39841620	mitochondrion Saccopharynx lavenbergi (Laven...	CDS	ATP8	4098	4265	normal
6	NC_005298	39841620	mitochondrion Saccopharynx lavenbergi (Laven...	CDS	ATP6	4256	4937	normal
7	NC_005313	40804706	mitochondrion Auxis rochei (bullet tuna)	CDS	ND2	4883	5929	normal
8	NC_004386	25057347	mitochondrion Hypoatherina tsurugae (cobaltcap...	CDS	COX1	5483	7033	normal
9	NC_005313	40804706	mitochondrion Auxis rochei (bullet tuna)	CDS	COX1	6317	7867	normal
10	NC_005298	39841620	mitochondrion Saccopharynx lavenbergi (Laven...	CDS	ND5	6829	8679	normal
11	NC_004386	25057347	mitochondrion Hypoatherina tsurugae (cobaltcap...	CDS	COX2	7206	7896	normal
12	NC_004386	25057347	mitochondrion Hypoatherina tsurugae (cobaltcap...	CDS	ATP8	7971	8138	normal
13	NC_005313	40804706	mitochondrion Auxis rochei (bullet tuna)	CDS	COX2	8023	8713	normal
14	NC_004386	25057347	mitochondrion Hypoatherina tsurugae (cobaltcap...	CDS	ATP6	8129	8812	normal
15	NC_005313	40804706	mitochondrion Auxis rochei (bullet tuna)	CDS	ATP8	8789	8956	normal
16	NC_005313	40804706	mitochondrion Auxis rochei (bullet tuna)	CDS	ATP6	8947	9630	normal
17	NC_005298	39841620	mitochondrion Saccopharynx lavenbergi (Laven...	CDS	ND2	10535	11584	normal
18	NC_005298	39841620	mitochondrion Saccopharynx lavenbergi (Laven...	CDS	COX1	11897	13612	normal
19	NC_004386	25057347	mitochondrion Hypoatherina tsurugae (cobaltcap...	CDS	ND5	11969	13807	normal
20	NC_005313	40804706	mitochondrion Auxis rochei (bullet tuna)	CDS	ND5	12790	14628	normal
21	NC_005298	39841620	mitochondrion Saccopharynx lavenbergi (Laven...	CDS	COX2	13749	14439	normal

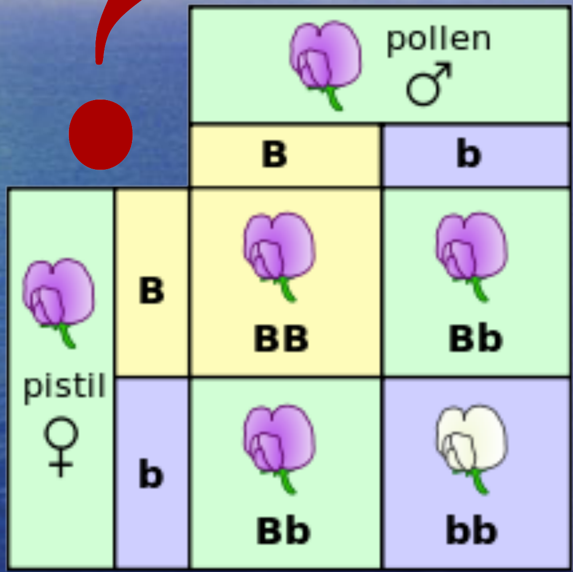


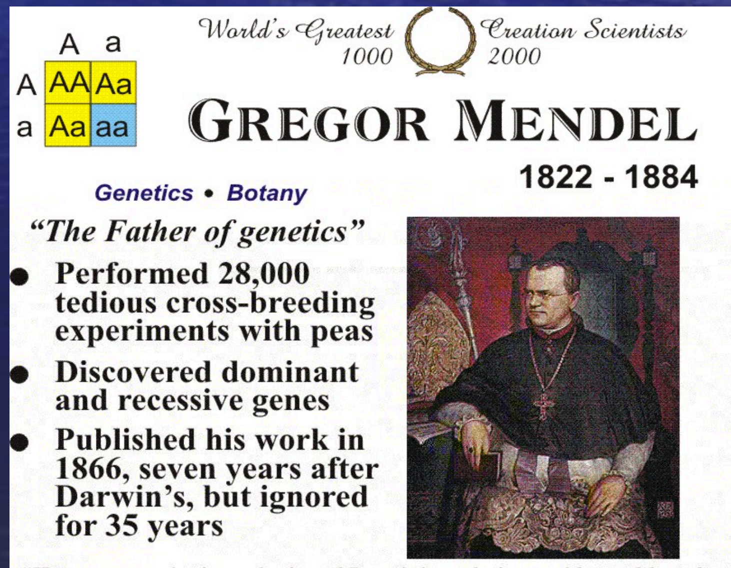
A Game that Deserves Rules

Mendel: Keeping Count !

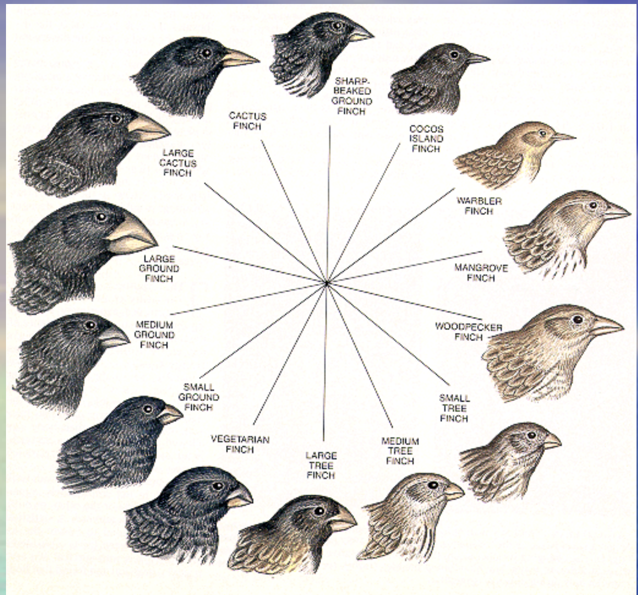


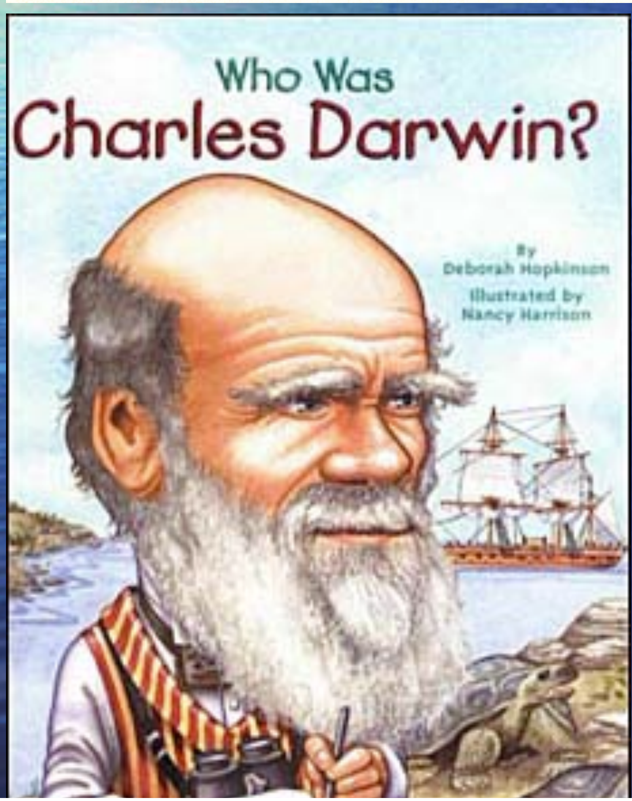
Courtesy of the Mendelianum, Moravian Museum, Brno.
Noncommercial, educational use only

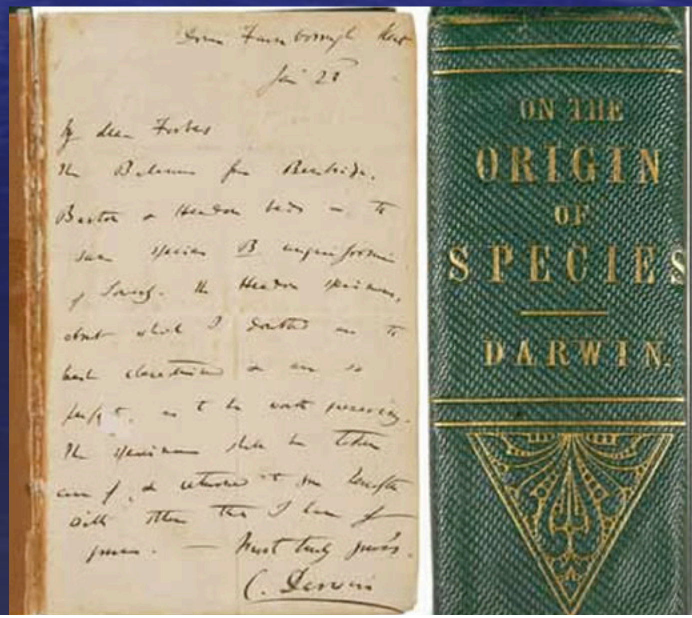




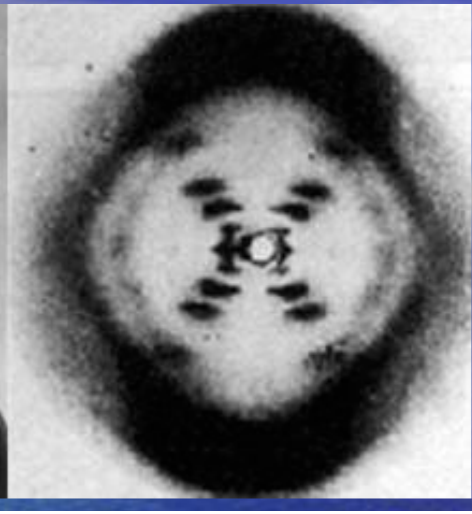
Of Beaks & Finches

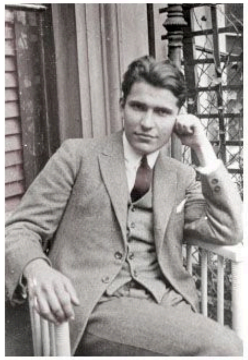




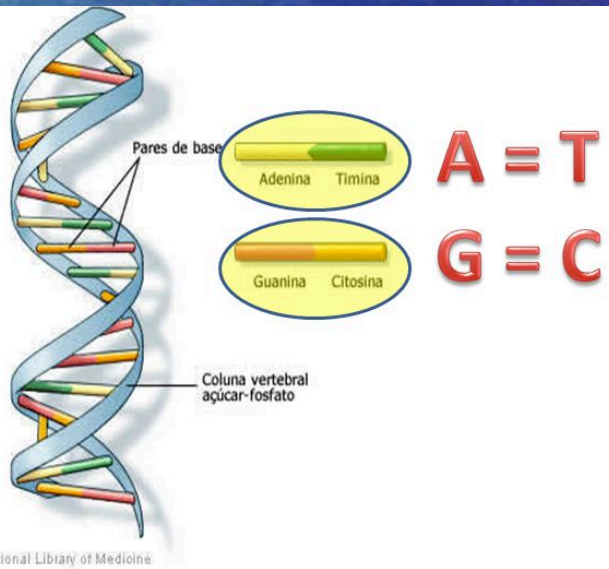


Playing by the Rules





Erwin Chargaff (1905-1992)



?

Why are some species rare, while others are invasive ?

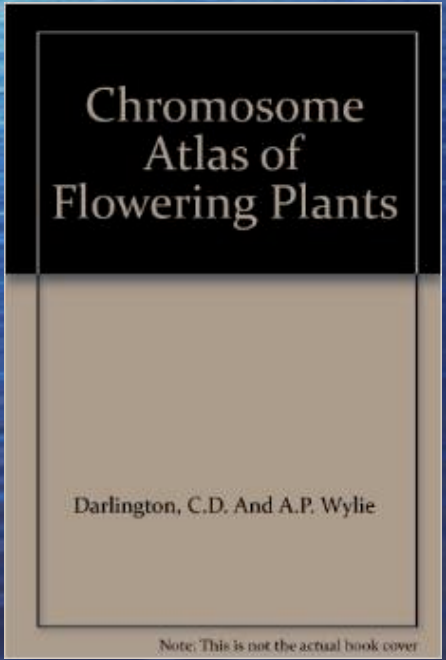
- The Phylogenetic Approach
- Ecological Approach [Invasiveness]
    - Allelopathy
    - Soil-microbe interactions
    - Enemy release
    - ECA

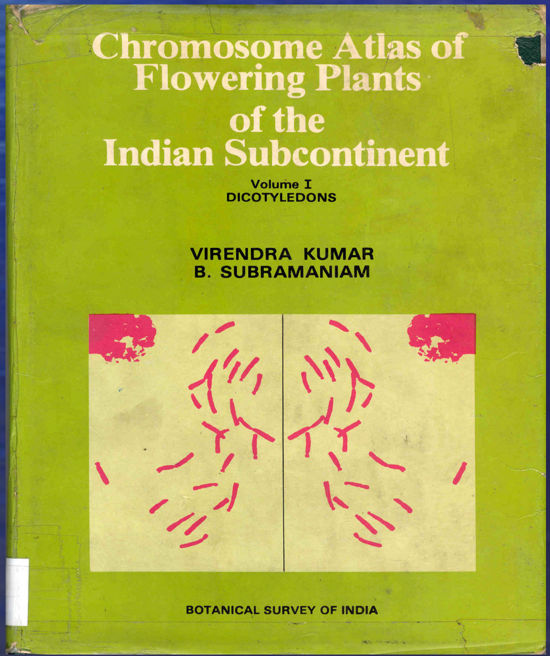
- A Different Approach
    - Intuitive - Genetical

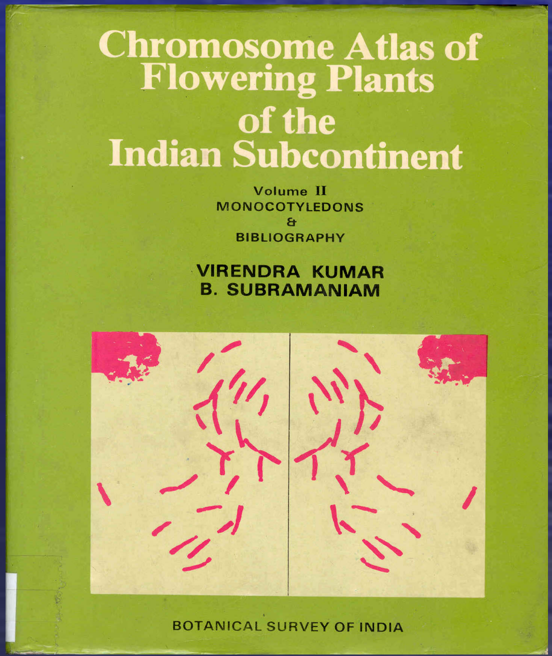
Database 1: First Searches

- Begin with home
- Indian endangered/invasives

Fedorov, A. A. (ed.) (1969) Chromosome Numbers of Flowering Plants







Database 2: Rare & Invasives

AGAVACEAE 465

AGAVACEAE Endl.

20/670 ; tropics and subtropics. 9/43 ; hotter parts of India, and Bangla Desh and Sri Lanka - many cultivated.

Agave Linn.

300 ; Southern United States to tropical South America. 6 ; cultivated and naturalized.

americana Linn.

20 Müller, C. 1912
60 MacKelvey, S.D. & Sax, K. 1933 ; Matsuura, H. & Sutô, T. 1935
60, 120, 180 (118, 119) Granick, E.B. 1944
120 Inariyama, S. 1937 ; Sharma, A.K. & Bhattacharyya, U.C. 1961c
120 (44, 96, 104, 110, 115, 125, 134) Sharma, A.K. & Bhattacharyya, U.C. 1962
120, 240 Satô, D. 1935b, 1938, 1942

cantala Roxb.

90 Doughty, L.R. 1936

sisalana Perr.

c. 138 Doughty, L.R. 1936
149 Granick, E.B. 1944
150 Inariyama, S. 1937 ; Vignoli, L. 1937 ; Satô, D. 1938, 1942

vivipara Linn.

60 Satô, D. 1935b, 1938, 1942 ; Mahabale, T.S. & Bhate, F.D. 1941 ; Sharma, A.K. & Bhattacharyya, U.C. 1962

wightii Drumm. & Prain

180 Sharma, A.K. & Bhattacharyya, U.C. 1961c
180 (52) Sharma, A.K. & Bhattacharyya, U.C. 1962

Cordyline Comm. *ex* Juss.

15 ; tropics and warm temperate. 2 ; cultivated or occur as escapes in the Eastern Himalaya.

australis Hook. *f.*

38 Bowden, W.M. 1940a, 1945a ; Rattenbury, J.A. 1957
120 Matsuura, H. & Sutô, T. 1935

terminalis (Linn.) Kunth

c. 152 Rattenbury, J.A. 1957

Dracaena Vand. *ex* Linn.

150 ; warm Old World. 9 ; chiefly distributed in Khasi Hills and Andaman Islands, and Bangla Desh - a few cultivated.

angustifolia Roxb.

40 Sarkar, A. K., Mallick, R. *et al.* 1977

draco Linn.

38 Bowden, W.M. 1940a, 1945a
40 Borgen, L. 1969 ; Bramwell, D. *et al.* 1972

metallica Hort.

14, 16, 21, 24, 28, 30, 32, 34, 35, 36, 38, 40, 42, 44, 46, 49, 50, 52, 56, 62, 63, 70, 77, 84 Datta, P.C. 1971a

terniflora Roxb.

80 Sheriff, A. & Singh, B.K.S. 1973

Furcraea Vent.

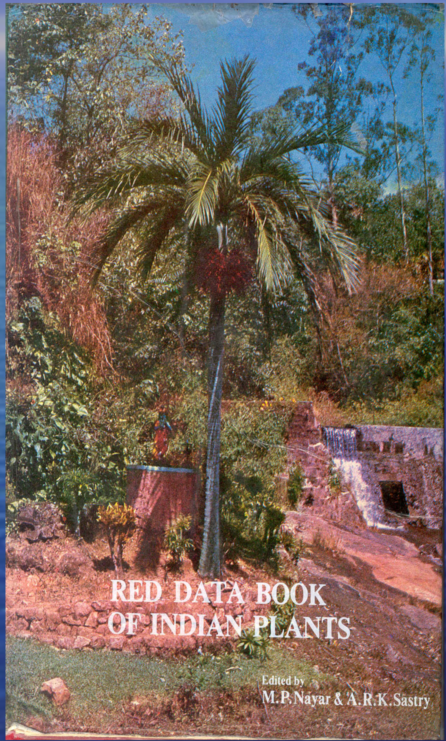
20 ; tropical America. 6 ; cultivated, a few naturalized.

bedinghausii C. Koch

60 MacKelvey, S.D. & Sax, K. 1933 ; Whitaker, T.W. 1934

foetida (Linn.) Haw.
gigantea Vent.

18 Catalano, G. 1930



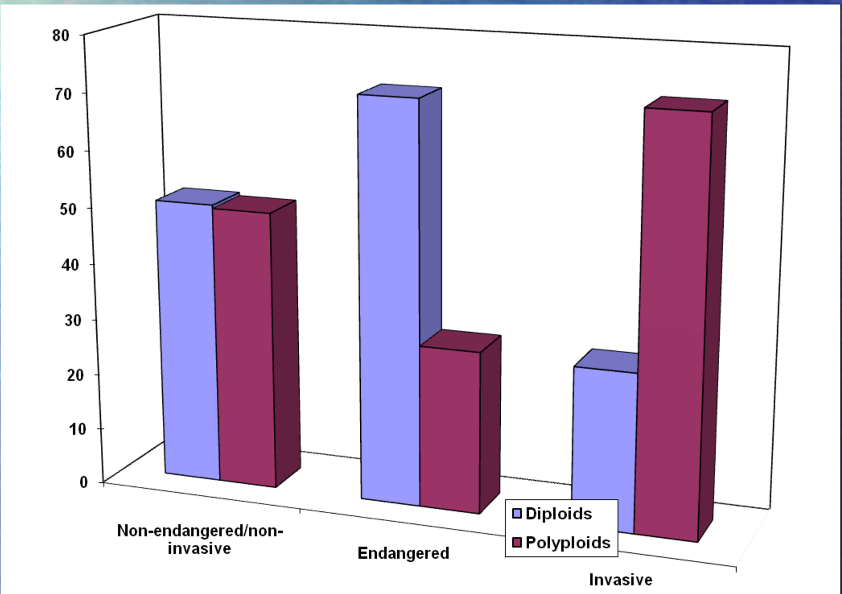
- Compared the preponderance of diploids and polyploids among the endangered species with those of the non-endangered species.
- Performed simple logistic regressions (logit model) of the probability of species endangerment and of species invasiveness as a function of chromosome number.
- Plant family was included to control for the effects of phylogenetic autocorrelation.

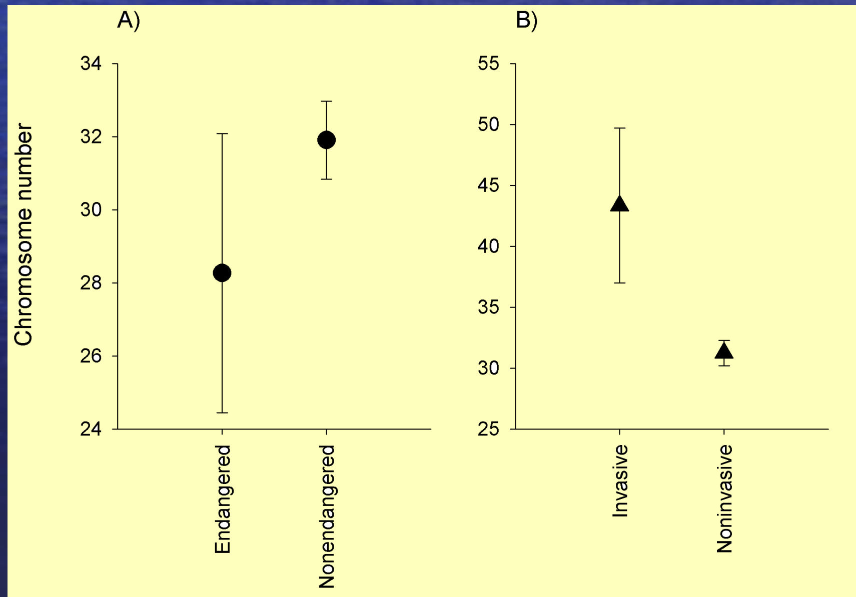
First Results

Evolutionary Ecology Research, 2006, **8**: 543–552

Continuing the search for pattern among rare plants: are diploid species more likely to be rare?

M.K. Pandit*





Mean chromosome number with error (95% confidence interval) bars (y-axis) for (A) endangered and non-endangered species (x-axis) and (B) invasive and non-invasive species.

How Robust Were the Numbers?

Table 2. Summary of results of the test statistics carried out in this study

Type of test	*Z*	*P*-value
Representation of diploids and polyploids in non-endangered species	0.896	0.370
Representation of diploids and polyploids in endangered versus non-endangered/non-invasive species	2.269	0.023*
Representation of diploids and polyploids in invasive versus non-endangered/non-invasive species	3.131	0.001**

* $P < 0.05$; ** $P < 0.01$.

Pandit, 2006

Sure it was Not Phylogenetic?

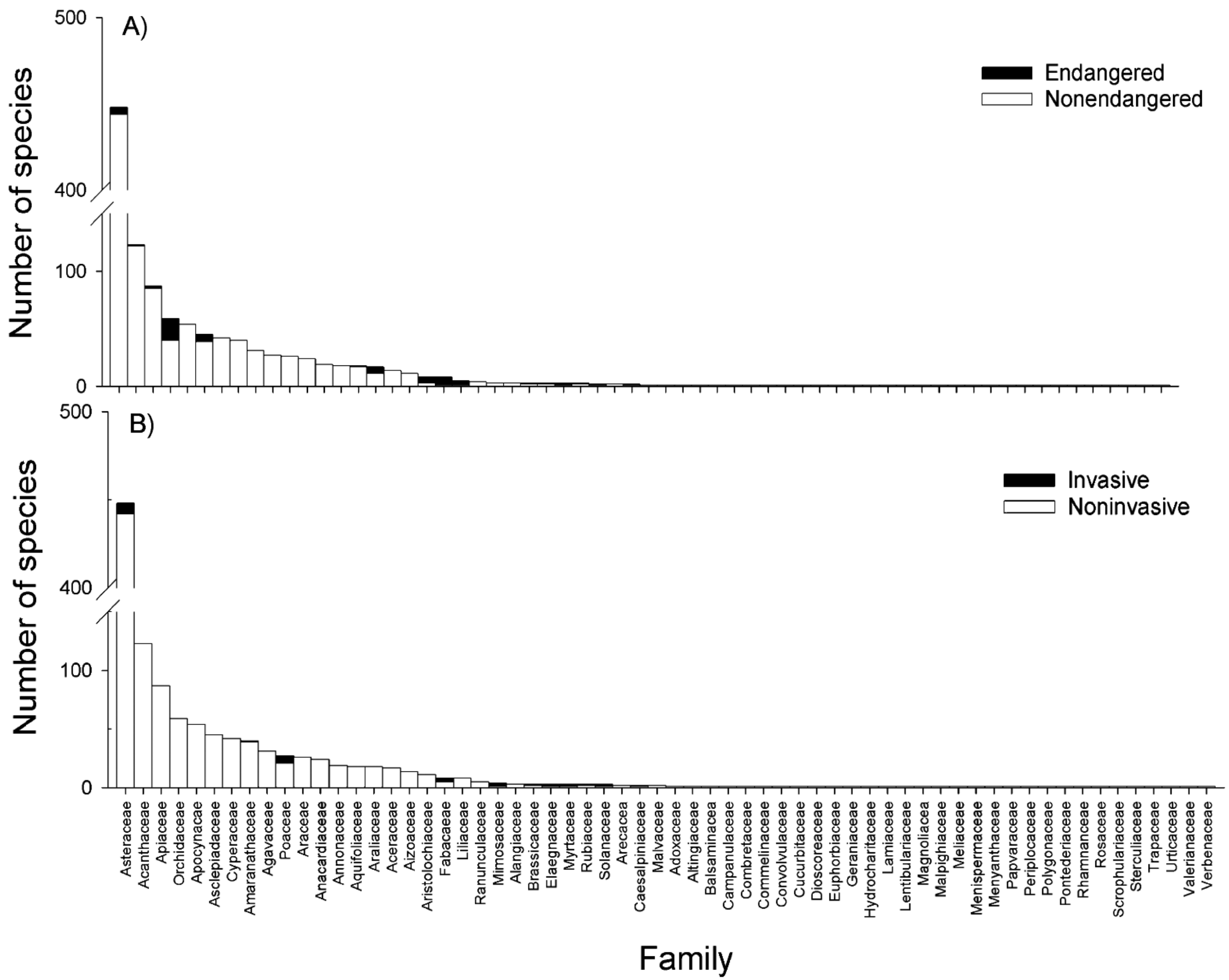
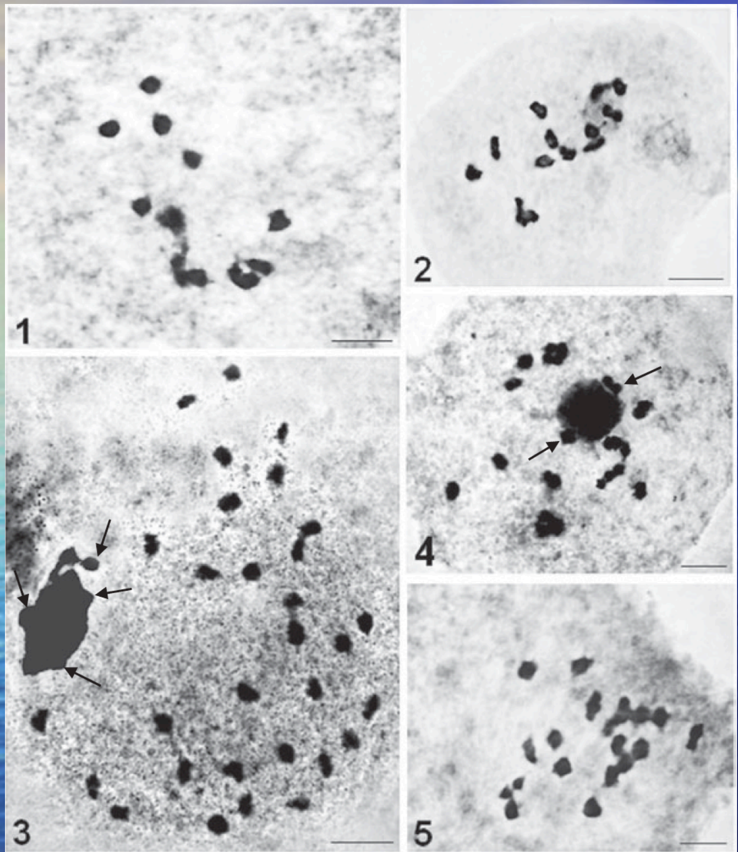


Fig. 1. The proportions of (A) endangered and non-endangered species (y-axis) and (B) invasive and non-invasive species (y-axis) for each family (x-axis).

Pandit, 2006

Where is the Empirical Evidence?



Male meiosis in some invasive species of Singapore. Fig. 1.*Asystasia gangetica* ssp. *micrantha;* 2. *Mimosa pigra;* 3. *Neptunia plena* ; 4. *Panicum maximum*; 5. *Urochloa mutica*

Scale bar = 4 µm.

All the investigated species were polyploids - allopolyploids

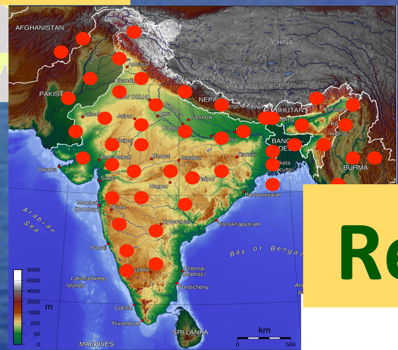
Botanical Journal of the Linnean Society, 2006, 151, 395–403. With 5 figures

Polyploidy in invasive plant species of Singapore

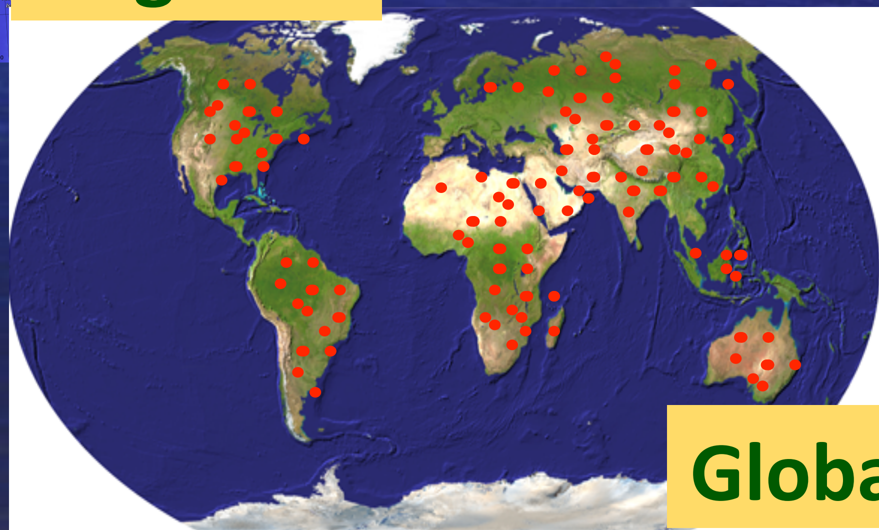
M. K. PANDIT FLS[1*], H. T. W. TAN[2] and M. S. BISHT[1]

Scales Matter

Area



Regional



Global

Databases & Present Investigations

- Endangered Species
  - IUCN (IUCN 2007) www.iucnredlist.org
  - Germplasm Resource Information Network, USDA [GRIN]
  - Species listed by the Center for Plant Conservation, classed as Endangered /Threatened by the U.S. Fish and Wildlife Service or in Appendices I and II of the CITES.
- Invasive species
  - Species listed in the Global Invasive Species Database (http://www.issg.org/database).
- Chromosome numbers & DNA C-values
  - Fedorov (1969); Kumar & Subramaniam (1985)
  - Online sources such as:
    - IPCN (http://mobot.mobot.org/W3T/Search/ipcn.html)
    - Royal Botanic Gardens Kew Database - http://data.kew.org/cvalues/CvalServlet).

GBIF & Present Research

- Genome size and cytogenetic traits vary according to latitude, with a peak at temperate latitudes (Bennett, 1987; Knight et al., 2005).
- We, therefore, extracted information on the distribution of each species from the Global Biodiversity Information Facility (accessed through GBIF Data Portal, data.gbif.org, 2013-02-04) .
- We calculated the average latitude of the centres of one-degree latitude/longitude grid cells in which the species had been recorded.
- The extraction of these data from GBIF was automated with the Rgbif package (Chamberlain et al., 2012) in R 2.15.2 (R Development Core Team, 2012), with additional code written by us to gather data on all the synonyms of each taxon under consideration (as listed by GBIF).

Thank You GBIF!!

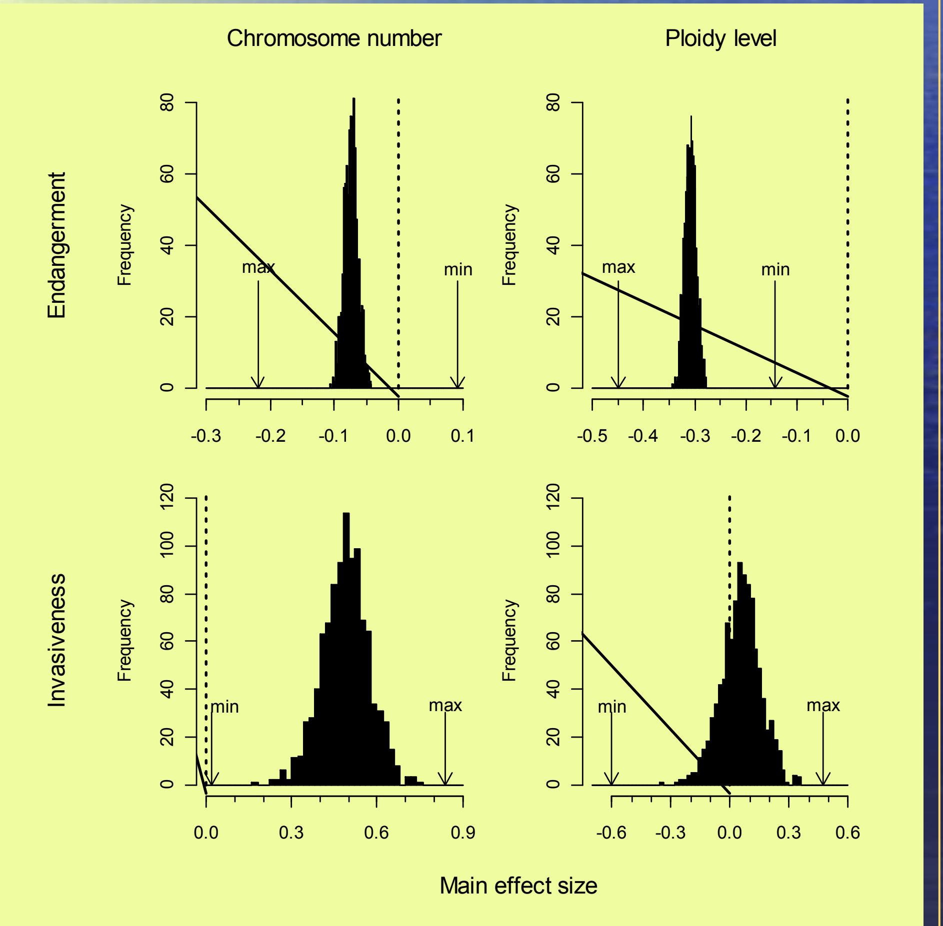
Journal of Ecology

British Ecological Society

Journal of Ecology 2011, **99**, 1108–1115 doi: 10.1111/j.1365-2745.2011.01838.x

Ploidy influences rarity and invasiveness in plants

Maharaj K. Pandit[1]*, Michael J. O. Pocock[2] and William E. Kunin[3]



- Chromosome # = 640 endangd. spp. (worldwide) + 9005 congeners, and 81 invasives + their 2356 congeners.
- We related ploidy to endangerment & invasiveness. We also related chromosome # (absolute number and relative to the minimum recorded for the genus) to endangermt and invasiveness with randomization test, taking the variation of reported chromosome # into account.
- Our findings - new hypotheses on plant rarity and invasiveness - influenced by genomic attributes; further our understanding of the role of ploidy in rarity and invasiveness in plants. Understanding the mechanistic basis of traits could aid conservation programs seeking to identify potentially endangered or invasive species.

Published online 6 April 2011 | Nature | doi:10.1038/news.2011.213

News

Ecologists find genomic clues to invasive and endangered plants

Findings could be used in conservation and control efforts.

Natasha Gilbert

Ecologists have discovered strong links between how many sets of chromosomes a plant species has and whether it is in danger of becoming rare, or conversely, becoming invasive. The findings[1] could help conservation scientists to predict whether species will need protecting or

Genomic data could help control invasive plants, like this kudzu in the south-

Stories by subject

- Ecology
- Genetics

Stories by keywords

- Plant genomics
- Invasiveness
- Rarity
- Ploidy

This article elsewhere

Blogs linking to this article

Related stories

- Sex change wipes out invasive species
  26 July 2007
- Invasive species: Shoot to kill
  16 November 2005

References

1. Pandit,M. K., Pocock, M. J. O. and Kunin, W. E. advance online publication doi:10.1111/j.1365-2745.2011.01838.x (2011).

Genome Size : General Results

We tested the ability of genome size (DNA 1C-values) to explain invasiveness and compared it with cytogenetic traits (chromosome number and ploidy). We considered 890 species from 62 genera, from across the angiosperm phylogeny and distributed from tropical to boreal latitudes

We showed - invasiveness was negatively related to genome size & positively related to chromosome number (and ploidy level), yet there was a positive relationship between genome size and chromosome number; that is, our result was not caused by collinearity between the traits. Including both traits in explanatory models greatly increased the explanatory power of each.

This demonstrates the potential unifying role that genome size, chromosome number and ploidy have as species' traits, despite the diverse impacts they have on plant physiology. It provides support for the continued cataloguing of cytogenetic traits and genome size of the world's flora

The Next Step : Genome Size

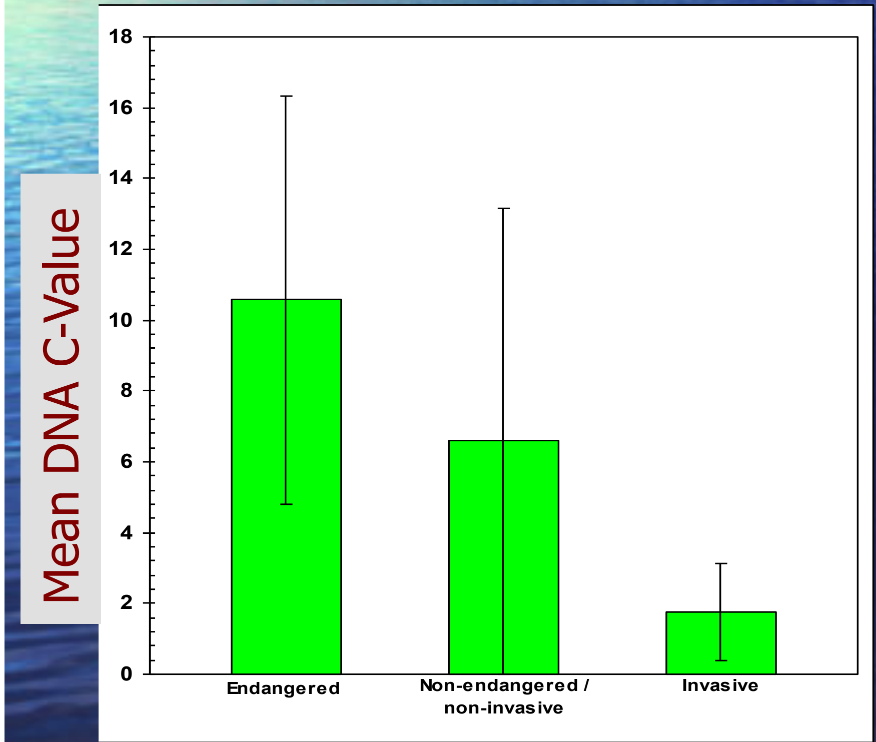
New Phytologist

New Phytologist (2014) **203:** 697–703

Research

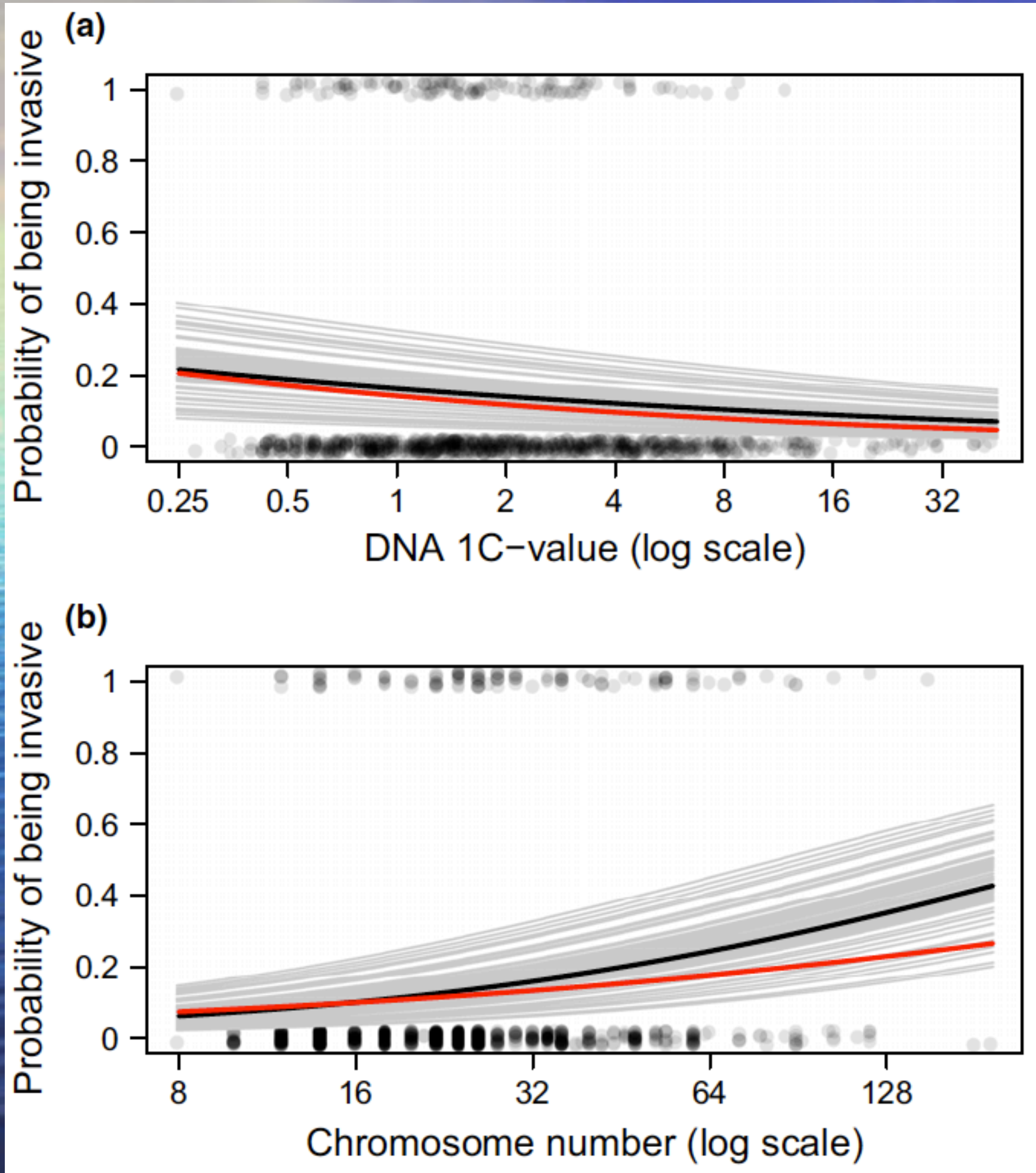
The contrasting effects of genome size, chromosome number and ploidy level on plant invasiveness: a global analysis

Maharaj K. Pandit[1], Steven M. White[2,3] and Michael J. O. Pocock[2]



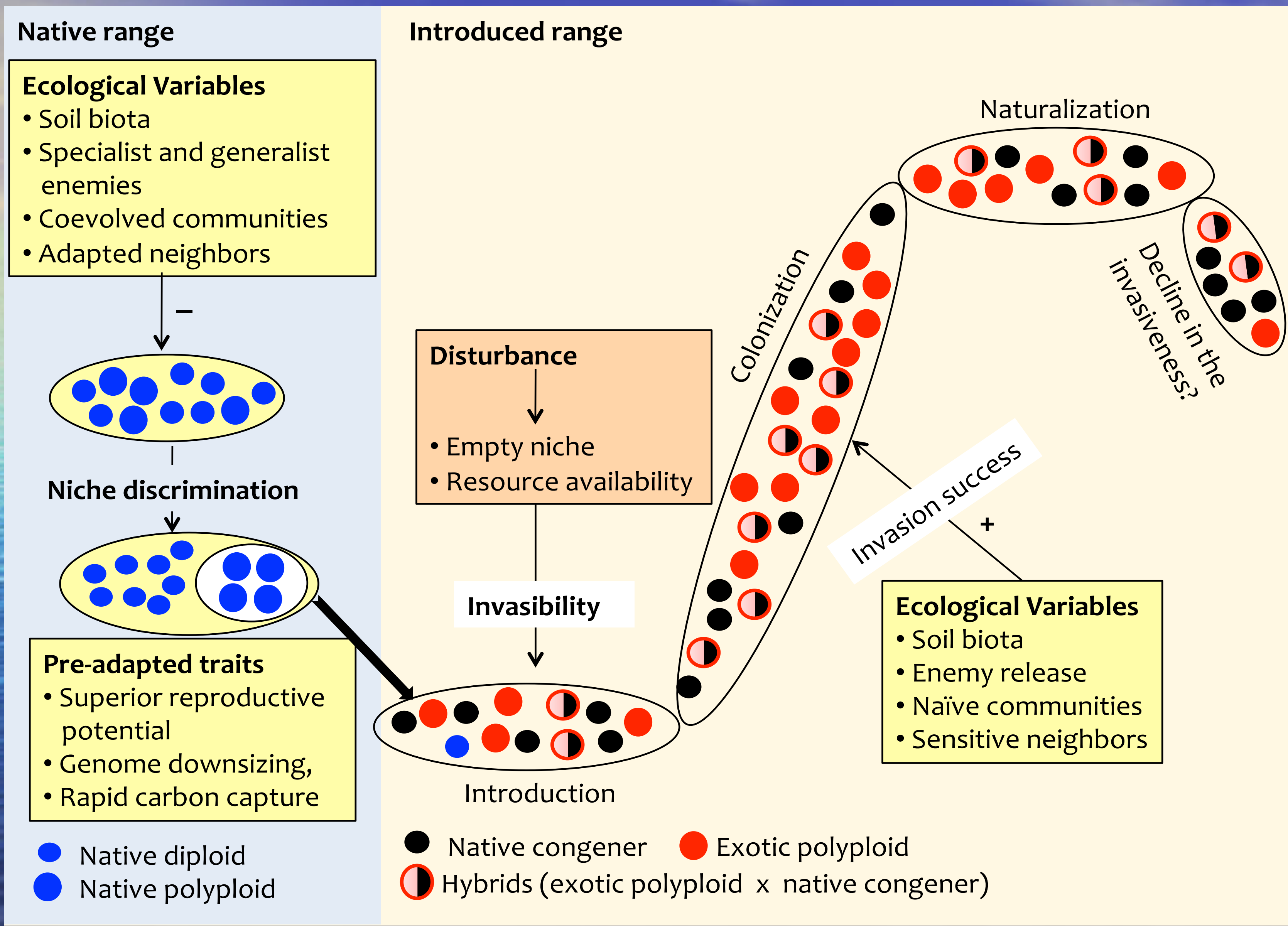
Comparison between the mean CDNA values of endangered, invasive and non-endangered/non-invasive plants (means ± standard deviation). Endangered plants had a significantly higher mean DNA C-values compared to non-endangered/non-invasive plants ($t = 11.67$, $p < 0.0001$). In contrast, invasive plants had a significantly lower mean DNA C-value when compared to non-endangered/non-invasive controls ($t = -22.71$, $p < 0.0001$).

Genome Size : Plant Invasion



The relationship of probability that a species in our dataset is invasive with: (a) genome size (DNA 1C-value);(b)chromosome number; In (a) and (b) the results of fully phylogenetically informed analyses (phylogenetic logistic regression; PLR) are shown in red, while, from the generalized linear mixed model, the overall average effect is shown in black and effects for individual genera are shown in grey.

Application Science - Ecogenomics



Pandit & Inderjit, unpublished

Databases & Invasion Research

- Enable us to make general predictions on macro-ecological theory.
- Assist us in quick screening of problematic taxa – both in conservation & invasion biology : Management & Control.
- Ascertain invasion history – herbarium record
- Help our decision-making process & allow us to make more informed policy choices?

Databases, Invasion Research & Policy

- One such important political framework covers Convention on Biological Diversity (CBD) and the Article 8h specifies: "*Each contracting party shall, as far as possible and as appropriate, prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species*".
- COP 5 Decision V/8 of CBD concerning "Alien species that threaten ecosystems, habitats or species" in its Guiding Principle 2 provides for "a three-stage hierarchical approach: (i) Prevention, (ii) Eradication, and (iii) Long-term control measures should be considered".

"If at one time or another I have brushed a few colleagues the wrong way, I must apologize: I had not realized that they were covered with fur."

— Erwin Chargaff,

Thank You