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# Teleomorphism in Speciation

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**Abstract:** The probable role of teleomorphism in speciation is proposed.

**Key words:** *Rhodotorula glutinis* · *Rhodosporidium toruloides* · speciation · teleomorphism

## INTRODUCTION

Teleomorphism is the process whereby teleomorphs are formed. Teleomorph is the stage of fungus where reproduction results from plasmogamy followed by kariogamy with sexual spores; as opposed to an anamorph. It is otherwise referred to as perfect stage or sexual stage. Many dimorphic fungi produce teleomorphs. A species is often defined as a group of individuals that actually or potentially interbreed in nature. In this sense, a species is the biggest gene proof possible under natural selection. The definition of species given above is difficult to apply in lot of places in nature. For example, many bacteria reproduce mainly asexually by binary fission. The definition of a species as a group of interbreeding individuals cannot be easily applied to organisms that reproduce only or mainly asexually.

Also, many plants and some animals form hybrids in nature. Hooded crows and carrion crows look different and largely mate within their own groups - but in some areas, they hybridize. Should they be considered the same species or separate species? If two lineages of oak look quite different, but occasionally form hybrids with each other, should we count them as different species? There are lots of other places where the boundary of a species is blurred. In this paper, using *Rhodotorula* as a case study, an attempt is made to give a probable future of Species.

**Unanswered questions:** There is a general concencious that species share common ancestors. But the unanswered questions are: - does the process of cellular advancement proceed slowly and steadily or it occurred in quick jumps? How does the different complications associated with different organs evolved? The most acceptable view is that since many of these complex traits seem to be adaptive, they are likely to have evolved in small steps through natural selection. That is, intermediate forms of the adaptation must have evolved before fully-fledged complex organs. But the intermediate forms of these adaptations may not seem adaptive, so how could they have been produced by natural selection?

**The genus *Rhodotorula* and its teleomorphs:** Traditionally, *Rhodotorula* has been regarded as the red yeast. Relationship between the genus *Rhodotorula* and its teleomorphs viz *Rhodosporidium toruloides*, *Rhodosporidium sphaerocarpum* and *Rhodosporidum diobovatum* is poorly understood. Isolation of the different teleomorphs of *Rhodotorula* from several environments has made different workers to hold different views about the ecological relationship of these organisms.

It has always been thought that *Rhodosporidium* has an Ustilago-like life cycle [1]. Banno [1] therefore established a new genus *Rhodosporidium*, within the ustilaginacea, a family of the smut fungi to include the single species *Rhodosporidium toruloides*. An additional genus *Leucosporidium* has been proposed by Fell *et al*. [2] to include fungi with *heterobasidiomycetous* life cycles and vegetative yeast phases in the form genus Candida.

Banno's work on sexuality in *Rhodoturala* was followed by the work of Newell and Fell [3], who described *Rhodosporidium sphaerocapum*, a spp distinctly different from *Rhodosporidium toruloides* but possessing a vegetative yeast phase identifiable as *Rhototonila glutinis*. *Rhodosporidium malvinellum* has been described by Fell [4]. This species was found among pink yeast strains from marine waters of the Antarctic. Newell and Hunter [5] isolated *Rhodosporidium diobovatum* from marine and brackish

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waters of Southern Florida. They indicated that all four *Rhodospoidium* species have been isolated from marine sources. *R. toruloides* has also been isolated from terrestrial sources.

From the above information, it seems that the four *Rhodosporidium* spp exist on their own as separate entities. This idea, that the four *Rhodosporidium* spp exist on their own as separate entities has kept on creating confusion about the relationship between *Rhodosporidium* and *Rhodotorala*. As a result, Newell and Hunter [5] admitted that the nature of relationship between the *Rhodosporidium* species and the parasitic members of the Ustilaginales remains unclear and raises questions about the ecology of these organisms. They then raised the following questions: - Are the *Rhodosporidium* species (i) strictly saprophytic members of the Ustilaginales, active in the environments from which they have been isolated; (ii) heterobasidiomycetes which are parasitic for organisms (e.g. algae, zooplankton) other than the higher plants which act as nests for the previously described ustilaginales; (iii) the saprophytic expression of facultatively parasitic smut fungi that are active in environment outside of their host plants, or (iv) identical to previously described smut fungi and existing only as inactive teliospores in the environment outside the host plant?

Newell and Hunter [5] thought possibility (iii) above lends ecological importance to the answer to the questions of *Rhodosporidium* identity. However this possibility failed to show the relationship between the *Rhodosporidium* and *Rhodotorula*.

Inability to provide explanation to the relationship between *Rhodotorula* and *Rhodosporidium* is probably the basis for the continuous confusion still experienced in the identification of yeast. So, despite the introduction of commercially available kits for rapid identification of yeasts [6-8) uncommon and newly described species present a significant challenge [9]. Dooley *et al*. [10] has even demonstrated a possible misidentification of yeast isolated by the use of updated Vitek Yeast Biochemical Card.

Confusion in yeast identification must be rapidly arrested as the significance of yeast species as a cause of human disease, particularly in the immunocompromised host has become more important in recent years. Factors responsible for the dramatic increase in the number of human disease caused by yeasts currently seen include AIDS, hemotological malignancies, organ transplantations, increased use of corticosteroid, antineoplastic drug treatment, complex surgical procedures and long-term indwelling vascular catheters.

The author has already shown that *Rhodosporidium toruloides*, *Rhodosporidium sphaerocarpum* and *Rhodosporidium diobovatum* are all produced directly by the teliospores of *Rhodotorula glutinis* [11]. Since *Rhodotorula glutinis* is present everywhere, its teliospores should also be found everywhere. These *teliospores* found in different environment may give wrong information about each teleomorph. It must always be remembered that each teleomorph is a direct descendant of a teliospore formed by the mother *Rhodotorula*.

Haase *et al*. [12] were the first to isolate reddish pigmented *Candida* (*Torulopsis*) *glabrata* from culture of stool of an immunocompromised patient. Initially, Haase and his group thought it was *Rhodotorula* and were very surprised when it was identified to be *Candida* (*Torulopsis*) *glabrata* by the following means: (i) biochemical profiling; (ii) gas-liquid chromatographic analysis of whole-cell fatty acid methyl ester [13] and (iii) sequence analysis of a 500 bp fragment of the $5^{1}$ end of the nuclear large ribosomal subunit rRNA gene [14].

To further differentiate between *Candida glabrata* and *Rhodotorola*, Haase *et al*. [12] performed micromorphology and susceptibility testing on the new isolate. They concluded that the micromorphologic traits of *Rhodotorula* spp are not characteristically different from those of *C. glabrata*.

Kerkmann *et al*. [15] isolated a red-pigmenting yeast strain between white growing *Candida* colonies on sabouraud-glucose agar. Surprisingly, further investigation of this strain revealed a candida-like morphology, the organisms forming chlamydospores on rice and yeast morphology on agar. On chromogenic agars and in rapid identification tests the strain showed a reaction positive for *C. albicans*. Biochemical tests showed affiliation of the red-pigmented strain with an ascomycetous yeast genus, excluding the possibility of the organism being a basidiomycetous *Rhodotorula* species. Since four radically Rhodosporidiumspecies could evolve from a culture of *Rhodotorula* as a result of plasmogamy followed by kariogamy with sexual spores it is tempting to suggest that speciation is simply a teleomorphic procedure. This idea sounds so convincing from the result of this experiment by the author. The yellow yeast stage of *Rhodosporidium toruloides* obtained as a teleomorph from *Rhodotorula glutinis* as already described [11] was mass-streaked on yeast extract agar and incubated for 24 h. The cells were then washed into a 4% glucose medium (five litres) in twenty litre bioreactor. The bioreactor was allowed to run for about 96 h. A yellow pigmented and/or colourless

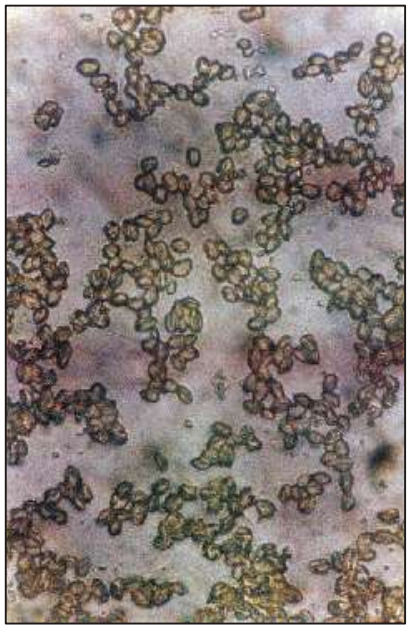

Fig. 1: Teliospore of *Rhodosporidium toruloides* x 100; (Courtesy: Oloke and Glick [11])

Fig. 2: Teliospore of *Rhodosporidium sphaerocarpum* x100; (Courtesy: Oloke and Glick [11])

mycelial mat was obtained. The mycelia were boiled for 6 h with water at 100°C to completely eliminate life from the mycelia. The boiled mycelia were incubated at 5°C for 60 days. Surprisingly, the surface of the extracted mycelia at such a low temperature was found to be covered with

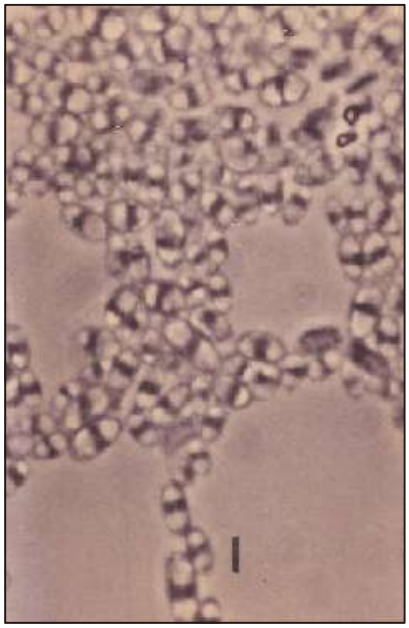

Fig. 3: Light microscope of *Rhodotorula glutinis* (Courtesy: Oloke and Glick [11])

both white and red colonies (Fig. 1). The red colonies were found to be *Rhdotorula glutinis*. When the mycelia of *Aspergillus niger* and a *Rhizopus* spp were treated similarly no such colonies were observed ruling out possibility of contamination.

Paul *et al*. [17] reported for the first time the isolation of a red-pigmented adenine auxotrophic *Candida albicans* strain from a sputum surveillance culture of a 19-year-old man suffering from pulmonary and gastrointestinal cystic fibrosis. In addition Haase [12] isolated a reddish-pigmented strain of *Candida (Torulopsis) glabrata* from a surveillance culture of stool of an immunocompromised patent. Hitherto, red yeast; *Rhodotorula* commonly isolated from human specimens are usually regarded as contaminants.

Oloke and Glick [11] observed that *Rhodotorula glutinis* behaved like *Candida bogoriensis* with regard to formation of crystal protein. When *C. bogoriensis* cells are grown on a glucose yeast extract medium, the organism produced two types of extra cellular lipids [18]. One was obtained as a liquid by solvent extraction of the cell-free culture left after centrifugation. The other product remained as crystals with the yeast cells. It should however be noted that *Rhodotorula glutinis* did not produce the lipid of *C. bogoriensis* in glucose yeast extract medium and the crystals of *R. glutinis* cannot be extracted with acetone and alcohol, as they are not soluble in those solvents. It is interesting to note that

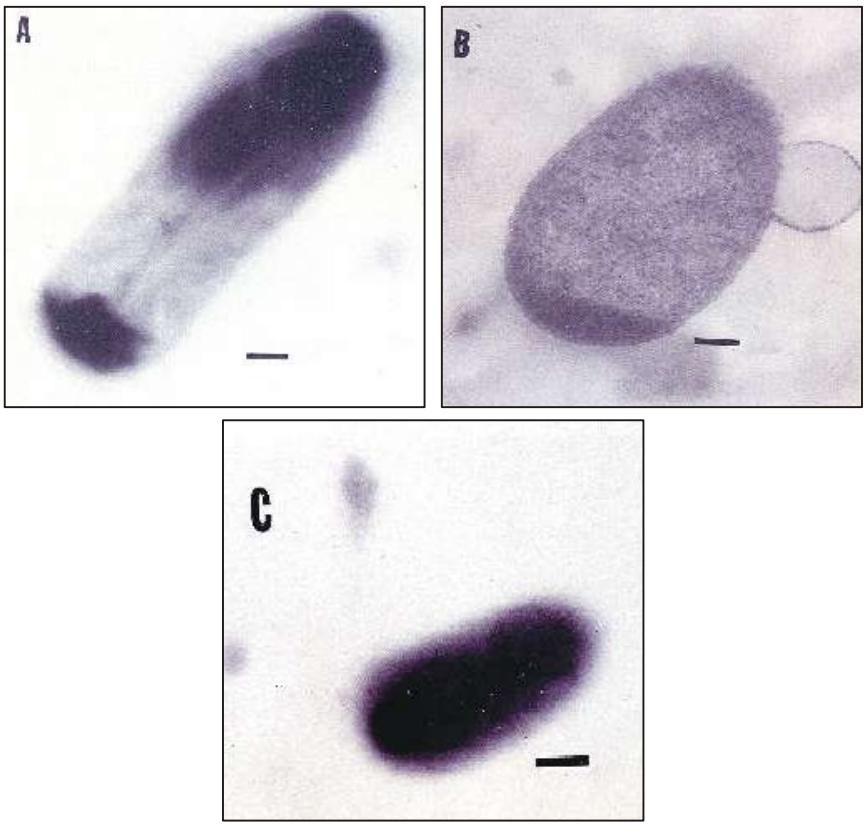


Fig. 4: Transmission electron micrograph of *E. coli* transformants carrying DNA from *Rhodotorula glutinis*. A = red transformant; B = large yellow transformant; C = small yellow transformant, Bar = 0.1 Nm (Courtesy: Oloke and Glick [16])

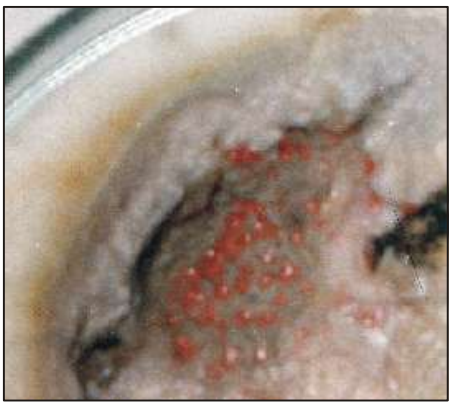

Fig. 5: Mycelial mass of *Rhodosporidium toruloides* covered with salmon/red *Rhodotorula glutinis* and white colonies of Candida

the crystal and the melanin gene of *Rhodotorula glutinis* have been successfully transferred to *Escherichia coli* (Fig. 4a) [16].

**Probable future definition of species:** It has been made abundantly clear that teleomorphism can lead to formation of radically different species from the mother cell e.g. *Rhodotorula glutinis* can form four radically different Species of *Rhodosporidium* with 60 days as a result of plasmogamy followed by karyogamy. If it is possible to produce four radically different Species from random mating of spores originating from *Rhodotorula glutinis*, is it plausible that several possible errors and/or mutations between plasmogamy and karyogamy will lead to the formation of either a more primitive or advanced cell than *Rhodotorula*? When this can be proofed a species may therefore be defined as a phenotypic expression of teleomorphism with or without its errors and its mutations. Since the intermediate form of natural selection may not be adaptive, the process of cellular advancement may not necessarily take million of years. It may simply be errors and/or mutations in the discrete processes of teleomorphism.

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