Fairy rings

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Popular Scientific Articles - STERF, June 2018

What is known about fairy rings?

Figure 1: *Mycelium from a fairy ring is clearly visible below the grass after removal of the plant layer. Picture: Campey Turf Care*

Each fairy ring consists of a single fungus colony growing and spreading below ground. The mycelium of the fungus grows radially out in a circle, and weakens in the middle as grass returns. Under favourable conditions, the fruit body of the fungus will sometimes be visible on the earth's surface, but the mycelium can grow within the earth a long time without fruit bodies on the surface and fairy rings (see for ex. Tronsmo, 2016; Figure 1).

The radius of the fairy ring can grow up to 1 m per year, and exists in forests, grass areas and on agricultural soil. The biggest known fairy ring is in Belfort in France, and it is 600 m in diameter. Fairy rings with an age of more than 1000 years exists. From times of old, myths and superstition has followed in the wake of fairy rings all over the world.

It's important to be aware that the fungus does not attack the grass directly or inflicts any true disease, but rather makes changes to the ground that are disadvantageous to the grass. The fungus is not a pathogen, and the effect on the grass is a response to the changed environment.

Fairy rings

The occurrence of fairy rings on golf courses are usually divided into three types:

Type 1: Dead grass in the ring
Extensive growth of mycelium in the ground creates both a poisonous environment and hydrophobic conditions making it difficult for the grass to take up water. The grass is damaged.

Type 2: Stimulated grass growth in the ring
Fungus releases nutrients which stimulates the growth of grass, which is mainly an aesthetic problem, but can to some degree the quality of the game on the greens. The grass is not damaged, but strong growth can make water infiltration inside the ring, and drought spots can occur at a later stage.

Type 3: Mushrooms growing in a circle
Mushrooms do not affect the growth of grass, but the mushrooms often grow on the edges of the circle. There is no initial damage to the grass, but damage can occur with removal of mushrooms through maintenance and invasion of weeds afterwards.

Figure 2. *Pictures: Margot Cumming, Reprinted from University of Wisconsin Gardner facts, 2 Nov 2016.*

Common to all fairy rings is that the fungi causing them all belong to the Basidiomycota division. 1,5 million different species of fungi exists, in which 10 % are identified and 30 000 of those belong to *Basidomycota*. In fairy rings around 100 different species have been found, and they all have different characteristics and may react differently to environment and treatment.

Ecological and biological studies also features other circular phenomena called fairy circles. They are caused by the cooperation and organization of insects, plants and other organisms growing in a circle. Studies of strange phenomena help solve the mysteries of how such structures form. Ruiz-Reynes (2017) found algae in the Mediterranean Sea (Pollenca Bay) that form big circular colonies. Vast areas in Namibia are home to wild grass growing in circles looking like fairy rings on golf courses. These rings have been shown to collapse, causing water to gather as in a reservoir. Thus humidity belowground increases and provides water for the roots growing on the edge of the circle. In Australia Getzin (2016) discovered a naturally occurring phenomenon in the way the desert maintained humidity in the ground. A small compact circle leads to the infiltration of water where the ground has a higher porosity, giving an advantage to the plants within the circle. Other nearby plants die, and over time several such circles are formed making a patchy circle-pattern on the ground.

Jennie Keighley from Great Britain recently held a lecture about her work on fairy rings at a seminar organized by Svenska Golfförbundet in Elmia September 2017. Based on the knowledge that mycelium in fairy rings affects the ability of grass to absorb water, Jennie Keighley studied the variations of volumetric water percentage in soils containing fungus (Keighley, 2017). She discovered the possibility of soil to reject water (hydrophobic) even with a water content at 13 %, while areas outside the fairy rings can be less water rejecting even when dried to 1 % water content. She also showed that in Great Britain, the problems with fairy rings are greatest in July and August (Figure 3).

Organic compounds are known to cause hydrophobia in sand grains and soil particles. Additionally, the mycelia and products of decomposition are important factors leading to problems with drought spots. According to a study by STRI, areas with dry grass have greater hydrophobic properties, but also areas within fairy rings where the fungus have passed, can turn water rejecting for a long period of time (York, 2000).

Suzuki (2016) recently discovered a growth hormone the fungus releases while growing. The hormone (2-aza-hypoxanthine) was isolated, resulting in the discovery that it also stimulates plant growth. Further studies feature the metabolism of the hormone in plants and fungi.

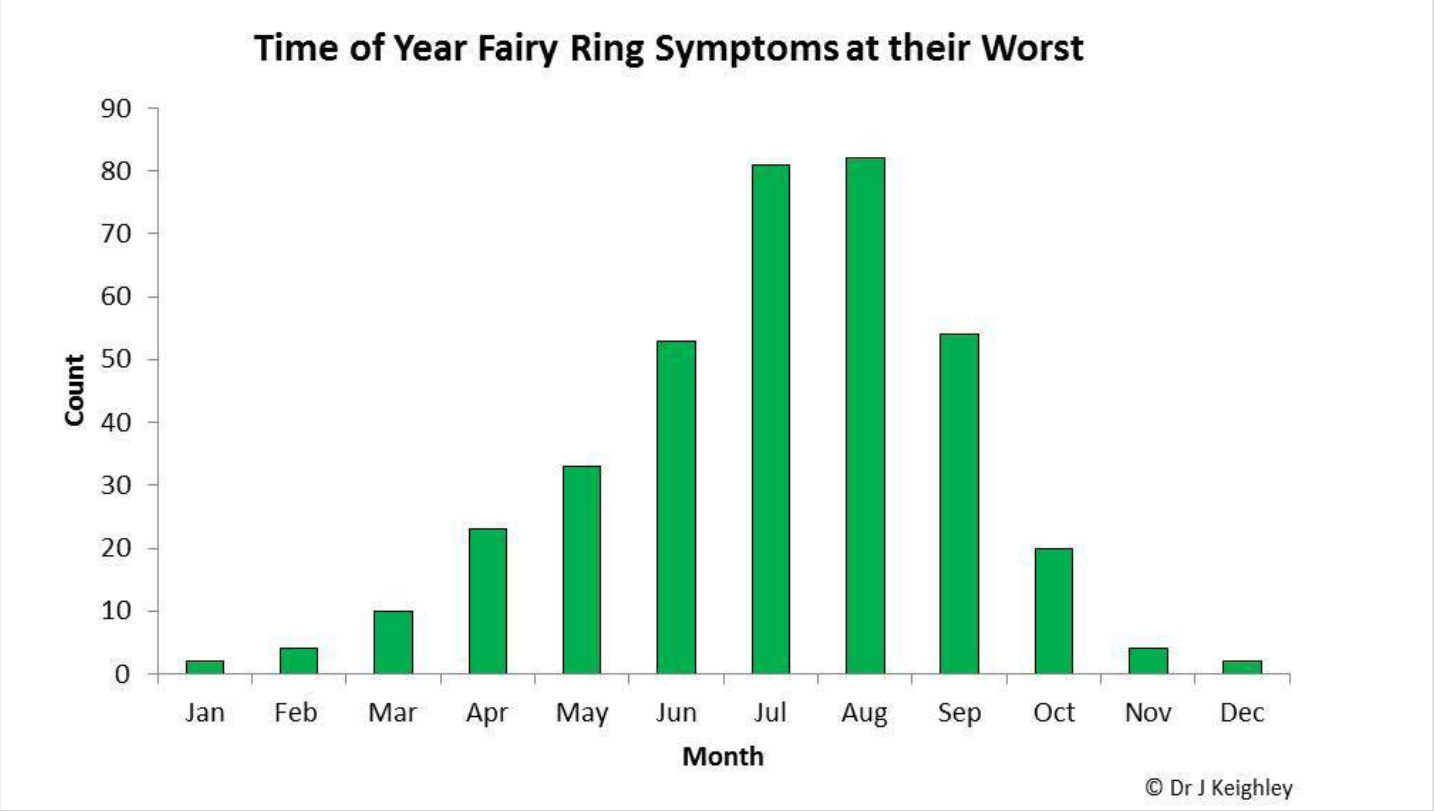


Figure 3: *The problems related to fairy rings vary throughout the year and are most severe in summer in Great Britain. From: Jennie Kieghley.*

Figure 4: *The most common fungi species in fairy rings: Type 1 Marasmius sp. (to the left), Type 2 Agaricus sp. (in the middle) and Type 3 a puffball fungus. Photos from Internet.*

Identification

Fairy rings Type 1 are often *Marasmius* species. The fungus has a dense mycelium growing down to a depth of 50 cm. The rings often occur subsided, and are visible all year round. It is common on fairways.

Fairy rings Type 2 are often *Agaricus* species. The fungus creates big dark circles especially in late summer. If the rings are thin and visible during both spring and autumn, it could be a Bovista species (puffballs) with a more shallow growth without visible mycelium in the soil. This is a common occurrence on golf greens.

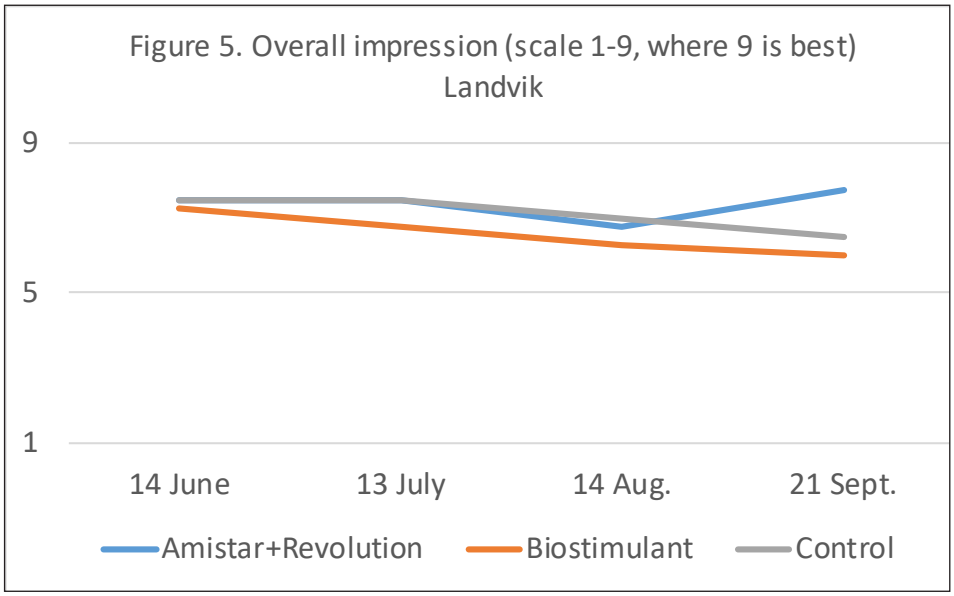
Fairy rings Type 3 does not have visible fairy rings in the grass, but fruit bodies growing in the circle. Common species are *Vascellu*, *Handkea* and *Lycoperdon*, often called puffballs.

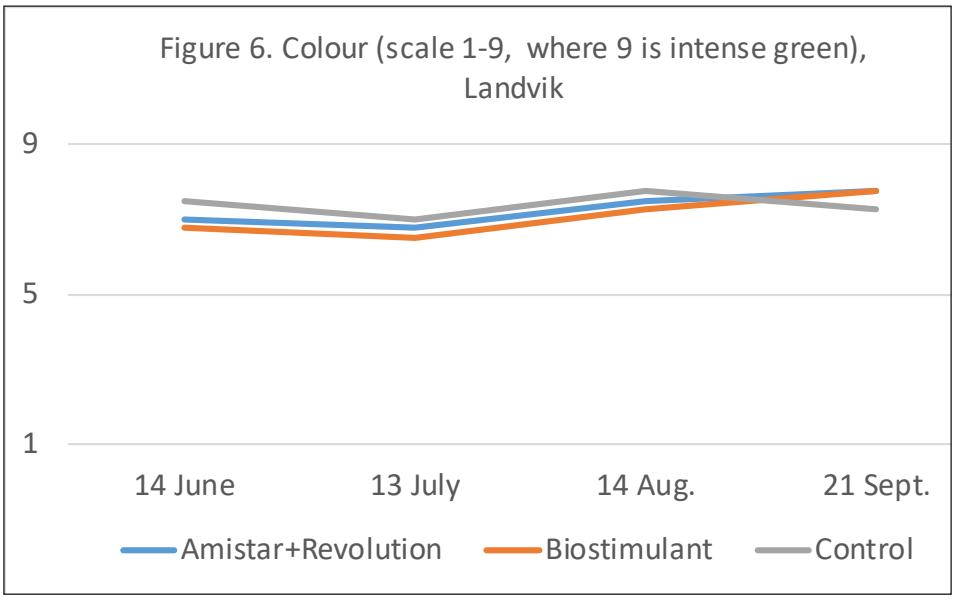
Because fairy rings belong to the *Basidiomycota*, they form basidiospores. Mushrooms produce spores underneath the cap. According to Jennie Keighley spores can be collected by sprinkling them onto a piece of paper, and the colour can help identify the fungus. In puffballs the spores mature before they move out through cracks in the fruit body. Fruit bodies contain billions of spores that spreads by wind.

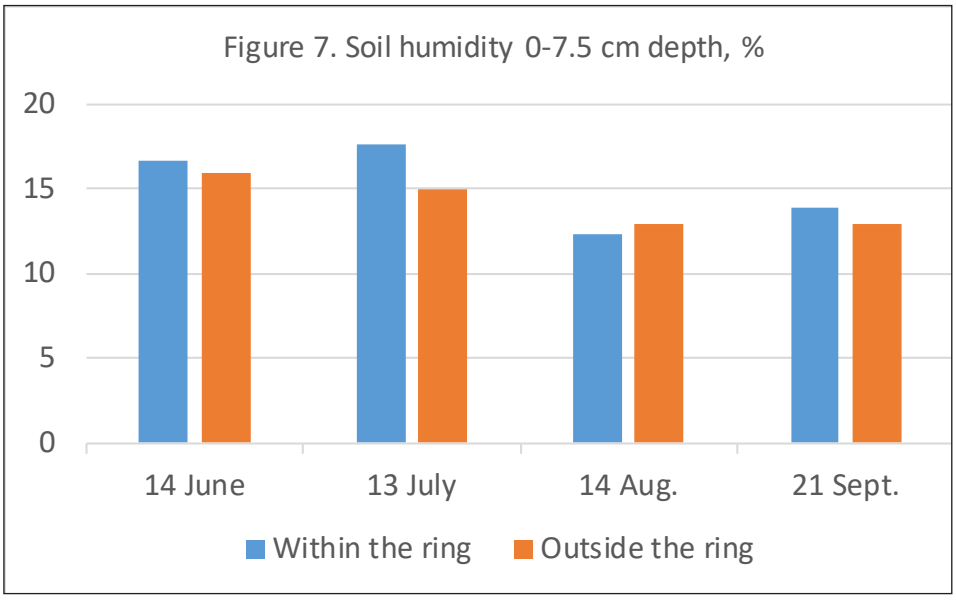
NGF and STERF project 2017 on fairy rings

In Norway, fairy rings have long been considered a cosmetic problem, but recent years have brought more questions to NIBIO concerning spots reducing game quality and killing the grass on golf greens. There is a higher frequency of areas in which the thatch decompose at a rate creating pits in the putting surface, that later develops to drought spots. Such drought spots are by some considered a result of increased use of microbiological treatments, wherein fungus spores are introduced on the greens to induce a greater biodiversity. There is no clear evidence for this. Furthermore, the exact organisms in question are also unknown.

A project financed by Norges Golfforbund through STERF in 2016 aimed to fight fairy rings on golf greens. NIBIO Landvik carried out an experiment with fairy rings on a 10 years old USGA green with creeping bentgrass (*Agrostis stolonifera* L.), a mix of the Penn-cultivars and Declaration) during summer 2017. The effects of a biostimluant (used 4 times; in June, July, August and September) and Amistar with the wetting agent Revolition (applied once, the 15th of June) on the size of fairy rings, overall impression of turf quality, colour and soil humidity down to 0-7,5 cm depth were studied.







Because the rings grew beyond the plots as early as July, their development could not be measured. The treatments were conducted as planned regardless, and there was little difference in the plots overall impression and colour between treatments (Figure 5 and 6).

Humidity was measured within and outside the ring (outside the experimental fields). Only July yielded results of 2,7 % higher humidity outside the ring than within, while the differences were inconsequential the remaining time (Figure 7).

Figure 8: *Type 2 fairy ring at Landvik at the beginning of the experiment in July 2017. Picture: T. Espevig*

Figure 9: *Type 1 fairy ring at Landvik in August 2017 (same ring as in Figure 8). Picture: T. Espevig*

Throughout the season the fairy rings developed from Type 2 (Figure 8) to Type 1 (Figure 9), at the moment believed to be *Bovista plumbea* (personal communication, M. Fidanza).

The fruiting bodies were visible by the end of August (Figure 10).

Figure 10: *Mushrooms from the fairy ring. Picture: T. Espevig*

The samples taken from the ring smelled like forest, the thatch was strongly decomposed and turning white in several places, but occasionally the thatch sported a red or orange colour (Figure 11). Contrary to the description of Bovista species' in chapter 'Identification', the mycelium was visible in the thatch layer.

In the second experiment on a pushup sand green with creeping bentgrass at Bjaavann, the effects of a biostimulant (the same as used on Landvik) were compared with the effects of the wetting agent Revolution alone (Figure 12). Both treatments were applied the first week of July, August and September. Revolution was also applied regularly on the whole golf course including the experimental green. This green is naturally vulnerable to desiccation because of a percolation speed at about 1600 mm/hour, which is at least 10 times faster than normal.

Figure 11: *The sample from the fairy ring to the left, in which the felt was more decomposed than the sample to the right, from a place outside the ring. Picture: T. Espevig*

Figure 12: *Experiment with fairy rings at Bjaavann GK, the 3th of August 2017. Picture: T. Espevig*

The fairy rings at Bjavann GK were only Type 2 from July to August. Early spring and late autumn the rings were not visible. No fruit bodies were found this summer. Because the rings were invisible the 6th of October, only two registrations of size and humidity were carried out: The 8th of August and 9th of September. Two rings went through each plot. The mean size of the rings went down from August to September (Figure 13), and this reduction happened faster in the control and biostimulated plots than plots with treatment of Revolution from August to September, while the opposite was true for September to October.

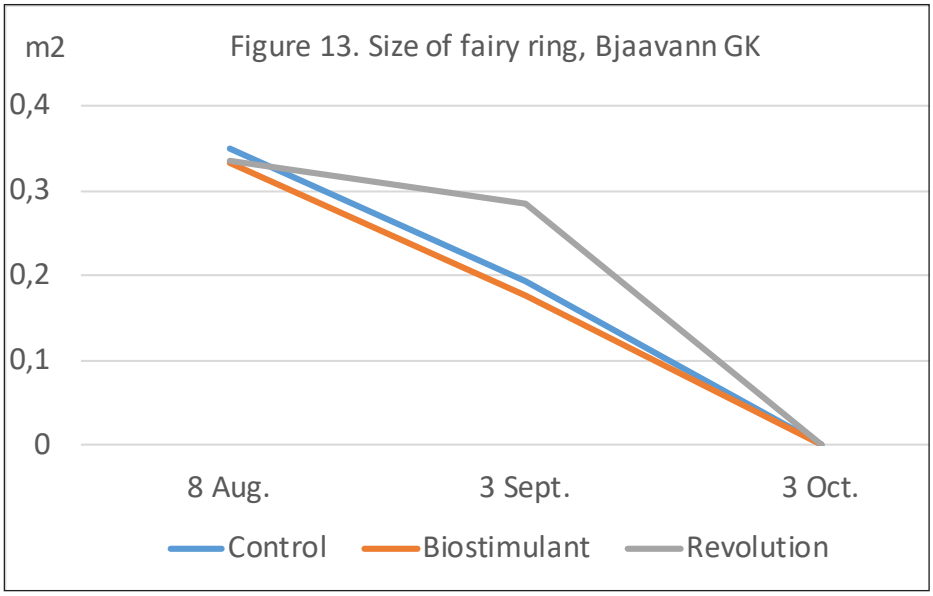


Figure 13. Size of fairy ring, Bjaavann GK

Humidity within and outside the rings were measured only once, the 8th of August. The humidity in control plots were found to be three percent higher outside than within the ring, while both Revolution- and biostimulant-treated plots had an approximately equal humidity within and outside the fairy rings (Figure 14).

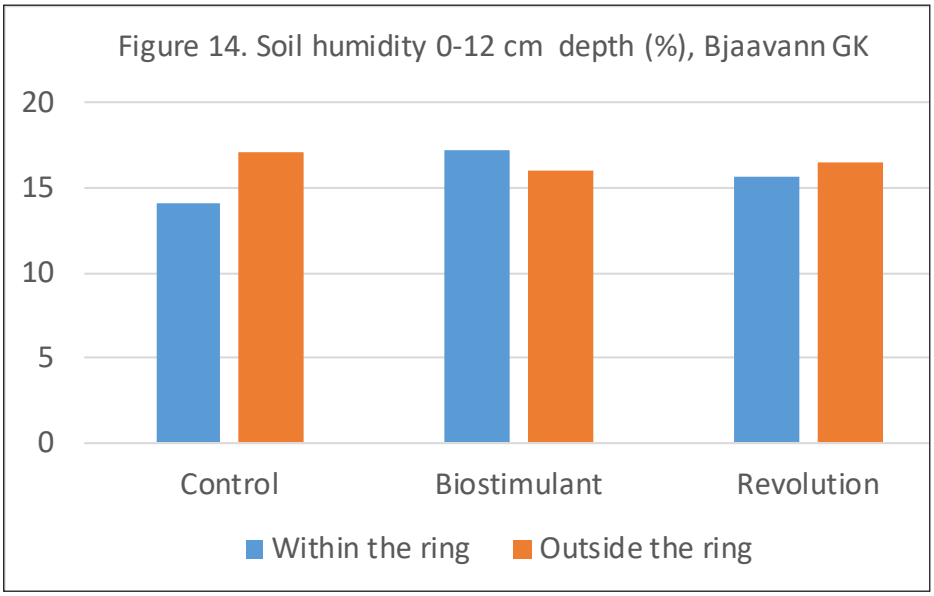


Figure 14. Soil humidity 0-12 cm depth (%), Bjaavann GK

Similar experiments as on Bjaavann GK were implemented in Gamle Fredrikstad GK where the problems were identified as 'thatch collapse'. According to Agne Strøm, so far there has been no observed effects of the treatments (the same treatments as at Bjaavann GK) on the fairy rings.

Small differences between treatments could be a result of too short duration of the experiment. Experiments should ideally be of a longer duration (preferably several years), and the application of biostimulant, fungicide and/or Revolution should be combined with airing for the treatments to move further down the root zone.

Measures against fairy rings

Common measures include fertilizing, watering, aeration and use of wetting agents, but the efficiency will vary according to the type of fairy rings.

For fairy rings Type 1 neither fungicides or wetting agents have shown to have any significant effect, probably because the fungus does not live inside the grass. Aeration combined with watering can influence the growth of Type 1 fairy rings. The main problem with fairy rings Type 1 is that soil becomes water repellent not due to traditional hydrophobicity caused by organic compounds between sand grains or soil particles but due to proteins excreted on the mycelium surface which are water repellent and cause hydrophobicity. The mycelium might obtain water repellent properties in early spring, and in some species' the effect is greatest in May.

Soil hydrophobicity due to water repellent mycelium is not the only cause of dead grass in fairy rings Type 1. *Marasimus* species', for example, releases hydrogen cyanide in the root zone, which might be poisonous to the grass roots (Blenis et al., 2004). This effect is comparable to how bacteria sometimes convert ammonium to nitrate in great enough amounts to be poisonous for the grass.

Water and airing treatments early in the season can sometimes reduce these problems.

Fungicides have no effect on fairy rings Type 2 caused by *Agaricus* species'. Possible preventive measures could be additional fertilization with nitrogen optionally with iron, which will make the rings less visible.
For fairy rings Type 3 the mushrooms usually grows overnight. The best way to handle them would be to remove the mushrooms by hand with soil before mowing, to prevent the mushrooms from being pressed into the thatch.

In Norway and the Nordic countries, no fungicide treatments for fairy rings are allowed. It is interesting to note, however, that previous studies from USA found fungicides to reduce fairy rings if washed down into the soil, and if used in combination with wetting agents (Fidanza, 2017).

The most important recommendation to prevent fairy rings is sufficient watering in early spring to prevent drought of greens, and right amount of watering throughout the growth season. Although labour intensive, mechanical removal of infested soil can also be done. In some instances the development of fairy rings can be stopped by turning the growth direction of the fungus 180°, causing it to run into itself and terminating further growth.

Fairy rings. Photo: M.Frisk

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