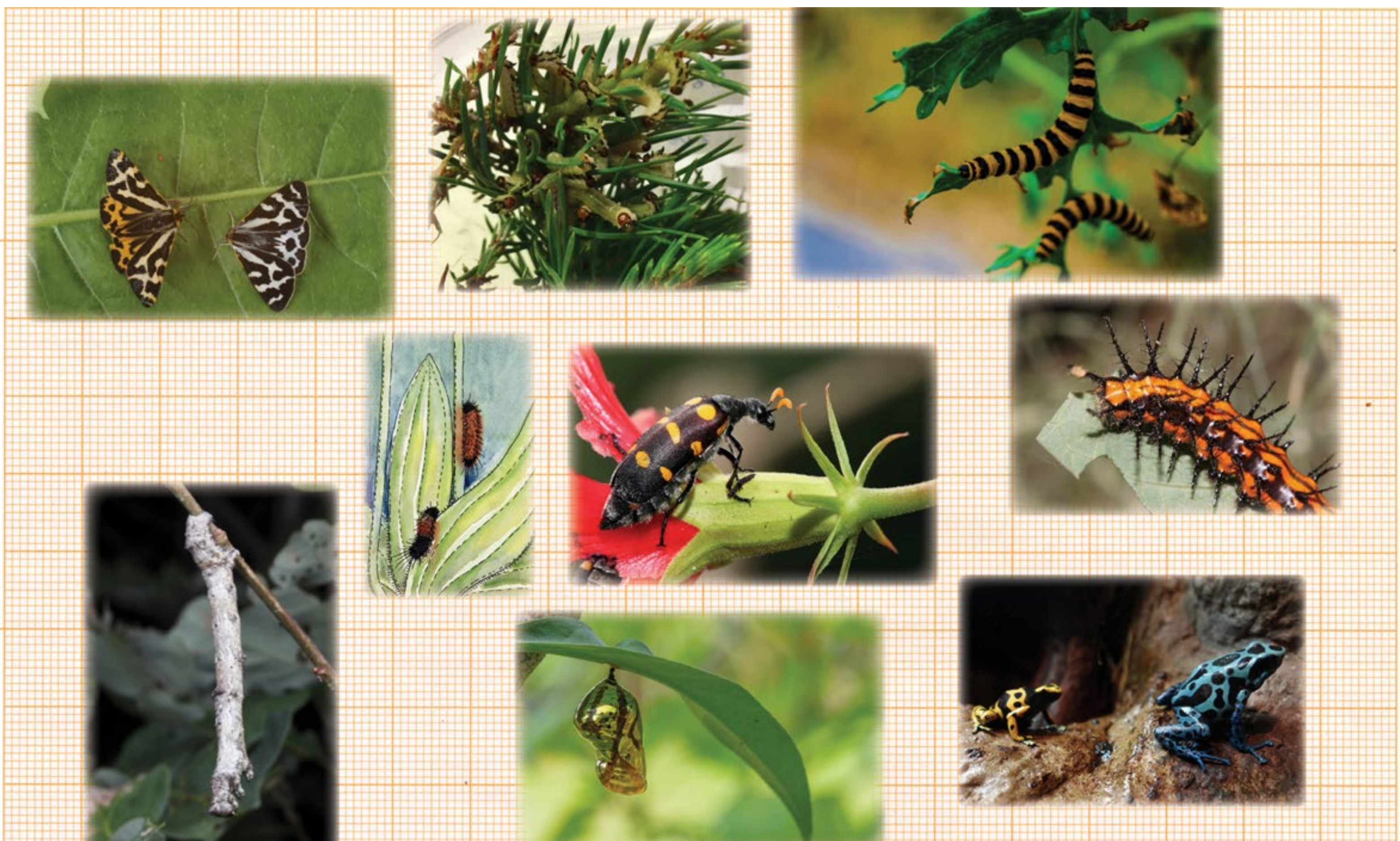
Evolution in Action

Interactive introduction to predator-prey interactions, different antipredator strategies and the evolution of protective coloration

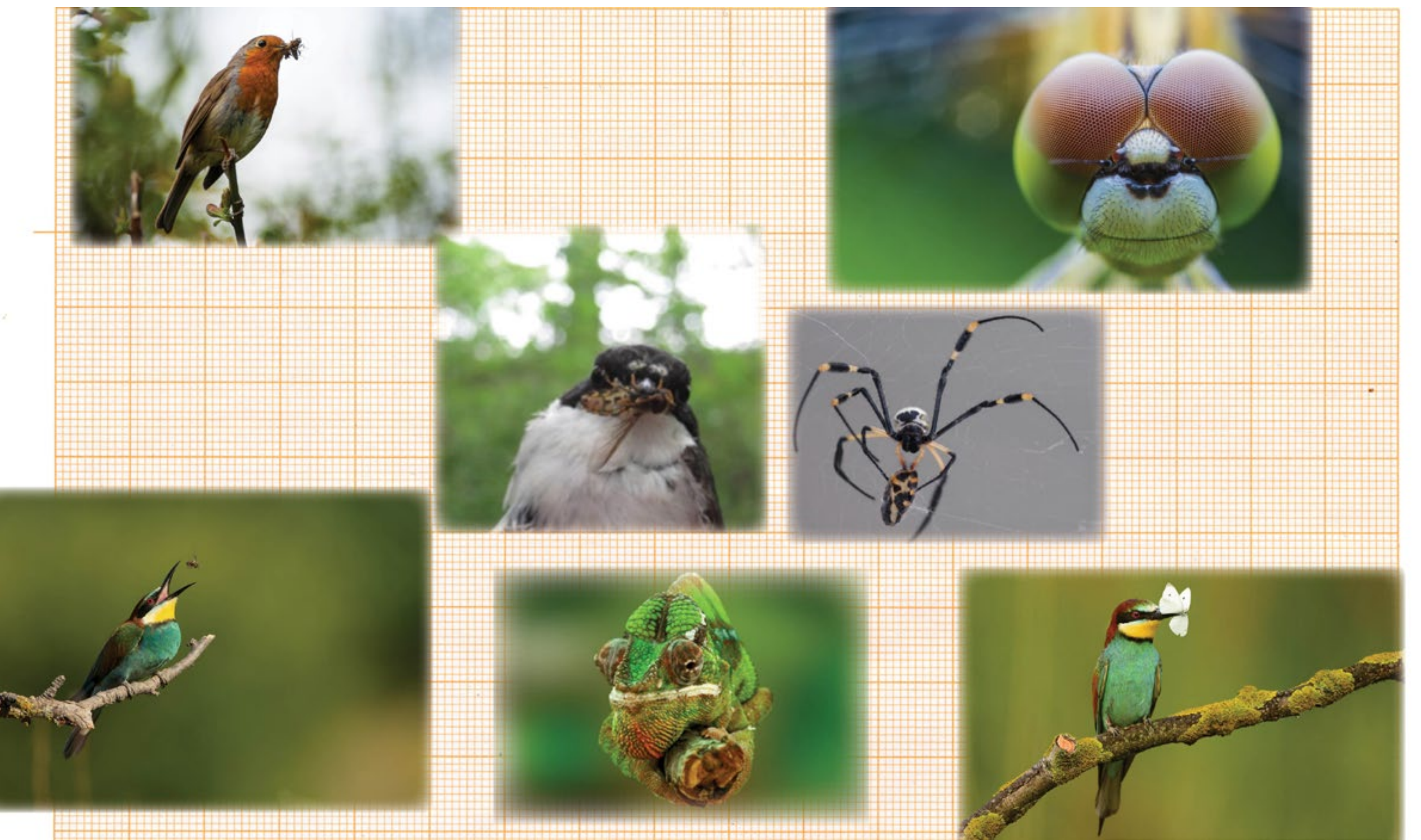
Slide 2

Let's think together about why living things are so differently coloured. Why are they not all similar in colour? *(Participants can brainstorm and suggest their own ideas.)*



Slide 3

Animal coloration can have many different functions. One of the most important functions is protection from predators. When researchers study how an animal's coloration affects its risk of being eaten, we need to focus on predators who use vision to find prey.
For example, insectivorous birds have a strong impact on the evolution of insect coloration. The majority of birds use vision to find prey, and they have very good colour vision. In contrast to humans, birds can also perceive ultraviolet wavelengths in addition to the wavelengths that are visible to humans. You can imagine that a birds' eye view of the world is "more colourful" than ours.



Slide 4

The most common way to be protected from predators is to rely on camouflage or cryptic coloration which makes prey difficult for a predator to detect.

Can you spot the prey items in these pictures?

You can hide from predator's eyes by relying on the camouflage or cryptic colour.

Slide 5

There are also other means to escape from predators via colouration. For example, prey can mimic something that is not edible or not interesting for a predator such as dead leaf, twig or bird poop.
In this picture you can see butterflies that mimic dry leaves and early instar *Acronicta alni* caterpillars that mimic bird droppings.
Some prey can mimic something that scares the predator. For example, some butterfly caterpillars can disguise themselves to look like a venomous snake; they puff their front end which together with their colour pattern and snake mimicking movements makes them suddenly look like scary venomous snake. This sudden appearance of the snake instead of a fat tasty caterpillar will scare the predator off in the middle of the attack and may save the caterpillar's life.

In this picture you can see a *Hemeroplanes triptolemus* caterpillar. This species lives in the Amazon.
You can find a video about the behavior of the caterpillar here.

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Slide 5

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In the other picture you can see a bee mimicking beetle who hopes that predators will confuse it with real bumblebees and not attack it. For the same reason many hoverfly species mimic bees and wasps and are avoided by predators who do not want to take the risk of getting stung.

Slide 6

The opposite strategy to camouflage is warning colouration, which animals use to advertise their unprofitability, toxicity or some other unpleasant characteristic (e.g. a wasp sting) to predators. Predators learn to associate detectable and bright colour patterns with the bad experience and will then avoid attacking similar looking prey items in future encounters.

We will come back to this later on.

Slide 7

Researchers have many ways to study how animal coloration and other defences against predators have evolved. For example, researchers can do behavioural experiments with predators such as insectivorous birds. Researchers can e.g. do experiments in enclosers or aviaries and observe which coloured insects (in this picture living wood tiger moths) birds will attack most.

Researchers can also use different types of artificial prey items that are totally novel to the predators. For example, in the 'novel world' method developed in the University of Jyväskylä, folded papers with different symbols on them each contain a piece of almond slice with or without a bad tasting chemical. The idea here is that a predator's previous experiences (e.g. nasty experiences with bad tasting insects) do not affect its choice of prey. This is beneficial if you want to study what factors affect a predator's ability to learn to avoid unpalatable prey initially. ›››››

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Researchers can also use dummy prey, which look like real insects or other prey species and study how often they get attacked in the wild. Here is an example of the fake wood tiger moth male (*Arctia plantaginis*) whose body is made from plasticine. The dummy moths that get attacked by birds will be left with V-shaped marks from the bird's beak which tells the researcher which dummys got attacked (beak marks on the body) and which did not (no beak marks on the plasticine body).

Slide 8

Here you can see a short video from a behavioural experiment where a pied flycatcher is hunting male wood tiger moths that are either yellow or white. You can try to follow whether the bird attacks the moth with yellow or white hindwings.

(The attack happens very quickly – you can ask participants how easy it was to observe and who got attacked?)

Slide 9

What is common between birds and humans?

(You can give your audience some hints: how do you find berries or mushrooms in a forest? How do you find your favourite chocolate bar in the shop?)

Answer: they both use vision to find food. *(Often you get lots of other suggestions as well. Remember to be positive towards all kind of participation.)*

Slide 10

Because humans rely heavily on our vision to interact with the world and we see lots of colours except for UV, researchers often use humans as predators in animal coloration studies.

So today you can be our predators in a predation experiment!

(Here you will need to go through the instructions for the Protective coloration game before asking participants to leave their places and organize into a que.)

Slide 11

After Protective coloration game.

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Let's revise a little bit.

Do you remember the two extremes in how coloration can protect prey?

Answer: Camouflage and warning colours.

Do you still remember how warning coloration functions?

Warning colour patterns are often large and simple as it makes them easier for a predator to remember and avoid in the future. You can compare how easy it is to remember and memorize the colour of some camouflaged prey (picture on the slide) vs. aposematically coloured prey.

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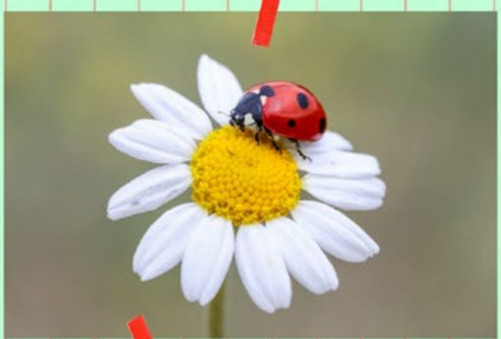
For example, if you get stung by yellow-black stripy wasp, you will be cautious whenever you see something yellow-black stripy – whether it is a harmless hoverfly or wasp or bee. You can also ask how many people in the audience have been stung by a wasp.



Slide 12

What do you think – what type of prey items were aposematic (= conspicuously coloured and unprofitable) in this game?
(Answer: yellow ones without the reward).

What were cryptic and palatable prey?
(Answer: black boxes with chocolate inside).

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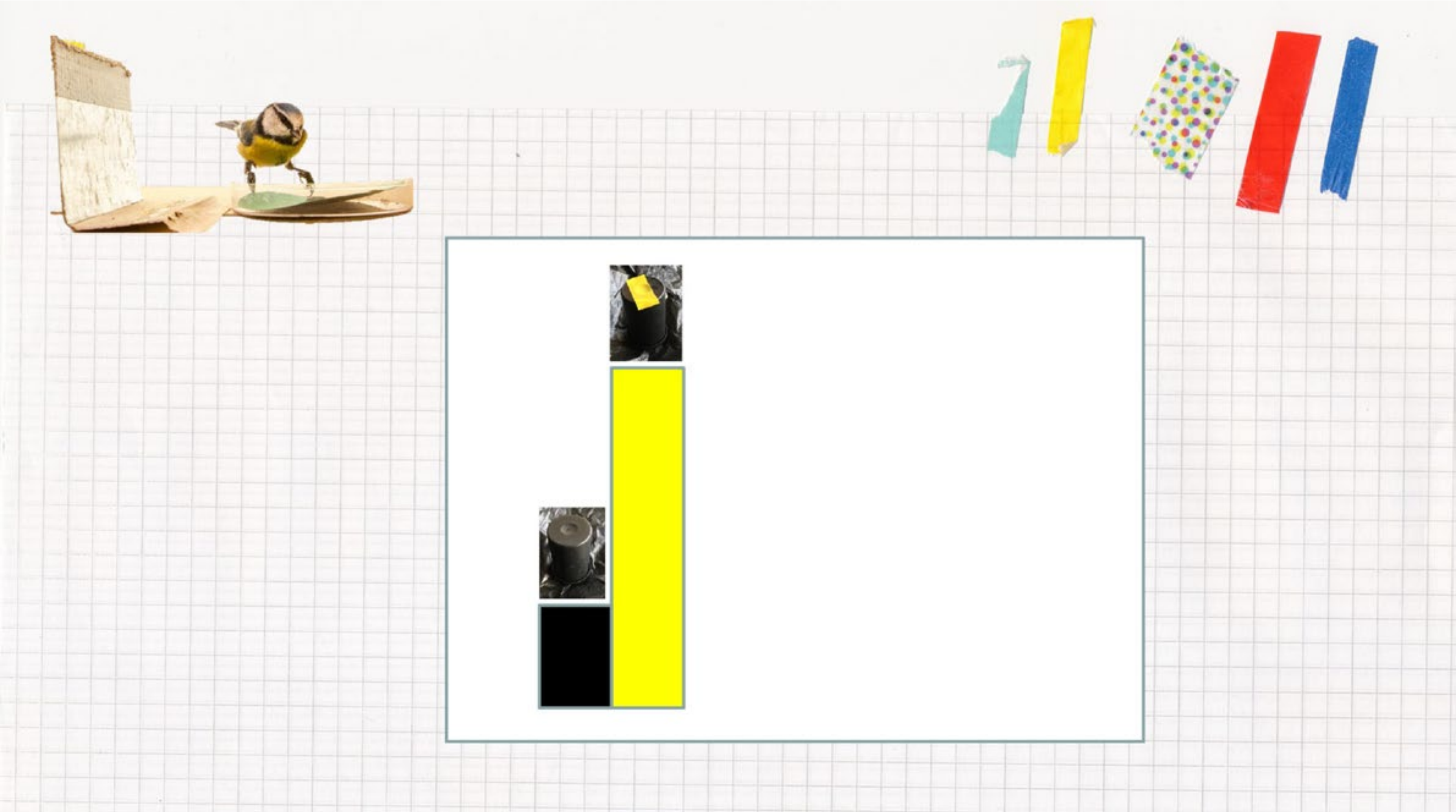
In this game aposematically coloured prey were unprofitable because they did not contain any food for the predator.

Slide 14

You can go through the results from the first round of the game here (please see the hypothesis in the Protective coloration game instructions). You can e.g. ask from participants why they attacked more warningly coloured prey in the first round?

Answer: In the first round, participants are likely to attack on the aposematic prey (black boxes with yellow marks) as they are more conspicuous and easier to detect. That is also what happens in nature where naïve bird chicks that leave their nest tend to attack the conspicuous



Slide 15

Video where you can see what happens when a blue tit attacks a warningly coloured and chemically defended wood tiger moth male.

Wood tiger moths have glands in their neck that, when threatened, produce defensive fluids which smell and taste bad to birds.
In the video, you can see the bird wiping its beak and shaking its head because the moth does not taste good. However, the defensive secretion of the moth is not dangerous for the blue tit.

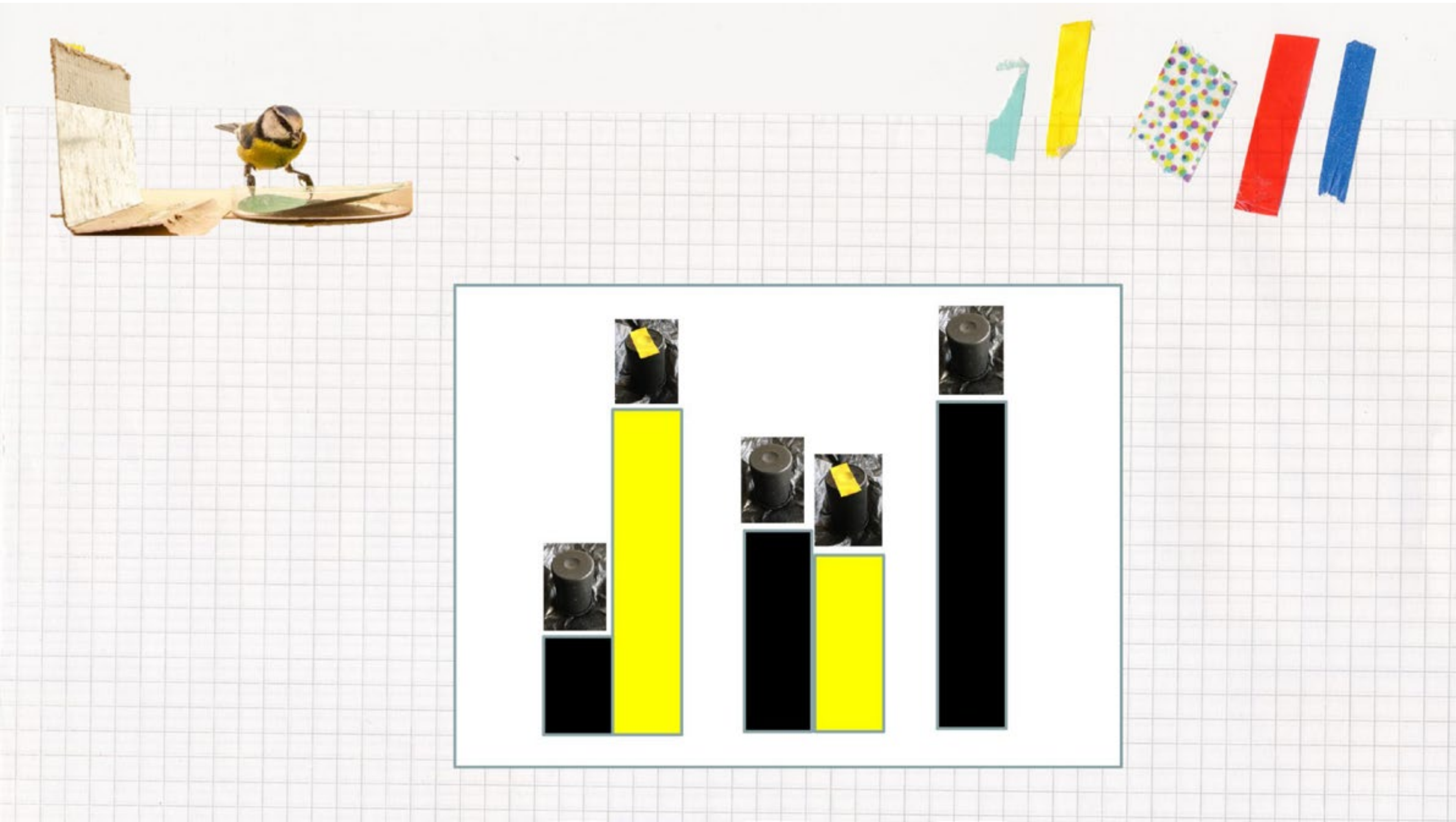
Slide 16

Slow-motion video of a blue tit attacking a wood tiger moth male.

Slide 17

Here you can go through rest of the results with participants.

How did your behaviour as predators change when you got more experience from different types of prey?
Did your predator group learn to avoid aposematic prey in the final round?
During the second and third round participants normally learn that it is better to choose the black prey boxes, which contain chocolate since they are more rewarding than aposematic empty boxes.



Slide 18

Our original question was why we have such a high diversity in animal coloration. Today we learned how predation shapes the evolution of animal coloration. We learned that predation can lead to different protective coloration strategies: camouflage, cryptic coloration, different types of deceptive coloration such as mimics of poisonous species, bird poop, twig mimics or snake mimics.

Why aren't all animals warningly coloured if it protects so well? What do you think?

Slide 19

As you noticed in the game, warning colours do not function well when you have lots of inexperienced naïve predators around like you were on the first round of the game.

Also, no defence is perfect and some predators can become e.g. less sensitive to defensive toxins that prey animals contain or they have learned to handle prey in a way that its defensive mechanisms do not hurt them. For example, bee-eaters (picture on the slide) can prey upon wasps and bees and handle them in a way that they do not get any stings. This adaptation and skill is very beneficial for them because now they don't have to compete with other predators for this food source. *(If you want to demonstrate resource competition and evolution please see our materials for Resource Competition).*

Some bird species have learned to 'cook their prey' in the sun which causes toxins of the prey to evaporate and makes the prey edible for them.

Sometimes the same defensive toxin that works very well against some predators does not necessarily deter other predator species. For example, even though many birds find wood tiger moths unpalatable, their defensive compounds do not work so well against spiders.

In addition, not all the defensive chemicals are noxious or toxic for a predator, some just make the insect taste mildly bad. For example, we all have some food that is not our favourite, but if you are really hungry you might settle for food that is not your first choice. Similarly in nature, if there is not much food available, birds can be more willing to attack chemically defended prey.

Altogether these factors affect how different types of protective coloration strategies function in the wild. Since there is variation in e.g. the abundance of naïve predators, the risk of being attacked by different predator species and differences the visual background that predators search for prey, evolution has resulted in a high diversity of beautifully coloured animals, which are each adapted to fit their specific needs.