Tropical Life Sciences Research, 25(1), 95–103, 2014

The Numerical Competency of Two Bird Species (*Corvus splendens* and *Acridotheres tristis*)

Nor Amira Abdul Rahman*, Nik Fadzly, Najibah Mohd Dzakwan and Nur Hazwani Zulkifli

School of Biological Sciences, Universiti Sains Malaysia, 11800 USM, Pulau Pinang, Malaysia

Abstrak: Kami telah menjalankan satu siri eksperimen untuk menguji kecekapan pengiraan dua spesies burung; *Corvus splendes* (burung gagak) dan *Acridotheres tristis* (burung tiung biasa). Kedua-dua spesies telah diuji dalam pemilihan tujuh kombinasi makanan yang berbeza dengan menggunakan ulat sebagai pilihan makanan. Kami berpendapat pilihan yang betul berlaku apabila burung memilih kumpulan makanan dengan jumlah ulat yang tertinggi. Keputusan keseluruhan menunjukkan bahawa burung tiung biasa dapat mengira dengan lebih baik (161 pilihan yang tepat daripada 247 pilihan) daripada burung gagak (133 pilihan yang tepat daripada 241 pilihan). Kami berpendapat burung gagak tidak bergantung kepada kepekaan terhadap nombor semasa memilih makanan. Burung gagak kebanyakannya memilih cawan yang mempunyai pilihan makanan yang lebih banyak tetapi kami mendapati bahawa daripada tujuh kombinasi makanan, hanya satu kombinasi adalah bererti. Sebaliknya bagi burung tiung biasa pula, ia menunjukkan prestasi yang perlahan pada permulaan eksperimen tetapi semakin progresif dalam aspek pengiraan sehingga ke akhir eksperimen (empat dari tujuh kombinasi makanan adalah bererti).

Kata kunci: Burung Gagak, Burung Tiung Biasa, Kebolehan Mengira, Perlakuan, Peka Nombor

Abstract: We conducted a series of experiments to test the numerical competency of two species of birds, *Corvus splendens* (House Crow) and *Acridotheres tristis* (Common Myna). Both species were allowed to choose from seven different groups of mealworms with varying proportions. We considered the birds to have made a correct choice when it selected the food group with the highest number of mealworms. Our overall results indicated that the Common Myna is able to count numbers (161 successful choices out of 247 trials) better than House Crows (133 successful choices out of 241 trials). We suspect that House Crows do not rely on a numerical sense when selecting food. Although House Crows mostly chose the cup with more mealworms (from seven food item proportions), only one proportion was chosen at rate above random chance. The Common Myna, however, were slow performers at the beginning but became increasingly more capable of numerical sense during the remainder of the experiment (four out of seven food proportion groups were chosen at a rate above random chance).

Keywords: House Crow, Common Myna, Counting Ability, Behaviour, Number Sense

INTRODUCTION

Numerical knowledge refers to the ability to count objects and to understand the relationship between numbers in small or large amounts. This trait of numerical

---

*Corresponding author: ramonaquincy@yahoo.co.uk

competence is found only in adult humans and consists of a variety of precise, stimulus-independent, numerical capabilities. Shared numerical competence, however, consists of a variety of approximate, stimulus-dependent, numerical capabilities, and is found in non-human animals, human infants and human adults (Katz 2007).

According to Tennesen (2009), number counting by animals may be an innate ability. Even without using actual numbers, animals can count and sum sets of objects. However, because they do not possess the linguistic sense of numerals, animals are not able to count verbally. Instead, the ability to count may have evolved for territorial animals as a way of determining whether to stay in an area by estimating the time invested to find food versus the amount of food found (Tenessen 2009).

The exact process of counting among non-human animals is still unclear and controversial. Most of the basic calculations for the counting ability of non-human animals follow Weber's Law. This law states that as numerical magnitude increases, a larger numerical difference is needed to obtain the same level of discrimination (Hunt *et al*. 2008). For example, most animals could differentiate the magnitude difference between one versus two or two versus three but will have difficulty comparing five versus six or six versus seven. Subitising is a numerical process that allows the observer to rapidly and accurately understand the number of small sets of objects, usually within the range of 1–4 items (Piazza *et al*. 2002; Balakrishnan & Ashby 1992; Kaufman *et al*. 1949). Counting is when enumeration is slower and is more prone to errors when more than four items are involved (Egeth *et al*. 2008; Piazza *et al*. 2002).

In recent years, the study of counting and other related numerical skills has been investigated across a wide range of non-human species. Studies have shown the potential for numerical discrimination in a variety of species ranging from honey bees (Dacke & Srinivasan 2008) and monkeys (Addessi *et al*. 2008) to ants (Reznikova & Ryabko 2011). Non-human primates have shown a more advanced numerical skill set compared to other animal species (Tomonaga 2008). Birds are considered promising subjects for the study of numerical competency based upon previous experiments (Shaw & Clayton 2012; von Bayern & Emery 2009; Hunt *et al*. 2008) that showed they possess abilities that were once considered unique to primates (Scarf *et al.* 2011).

Because corvids are famous for their intelligence and boldness, they have garnered much attention and interest from the scientific community. For example, corvids are capable of using and making tools to catch prey (von Bayern *et al*. 2009). Corvids will use sticks (and sometimes even modify a stick) to acquire bugs or other food from crevices and small cracks (Kenward *et al*. 2006). When necessary, corvids have even been known to successfully bend a piece of wire into a hook to obtain their food (Weir *et al*. 2002). Some corvid species, such as the common raven (*Corvus corax*) (Bugnyar *et al.* 2007), have solved the challenging task of keeping track of a moving object, a skill similar to that observed in human infants. Despite known as a fast-learning and intelligent bird species (Yosef *et al.* 2012), little is known about the ability of corvids to quantitatively judge inequality, and whether these numerical judgements in wild animals have any adaptive significance is still unclear (Hauser *et al.* 2000).

Starlings are another bird group considered to be intelligent due to their ability to recognise trees and people in pictures and also due to their vocal identification signalling (Kak 2000). Heptonstall (2010) stated that some species of starlings [in particular, the Common Hill Myna (*Gracula religiosa*)], also have the ability to mimic human speech as well as other environmental sounds.

Corvus splendens (House Crows) and *Acridotheres tristis* (Common Myna) are considered nuisance and pest species and are usually associated with a dirty environment and noise pollution. Both of these starling species are found in Malaysia and Pulau Pinang. The main objective of this study was to evaluate the numerical competency in two species of birds, *C. splendens* (Family: Corvidae) and *A. tristis* (Family: Sturnidae).

MATERIALS AND METHODS

The Common Myna is a small bird species with very distinct features. The body is brown with a greyish-black hood, whitish vent, and a yellow bill and facial skin. The House Crow is slightly bigger than the Common Myna and is black with a sharply contrasting, pale grey collar. The bill of a House Crow is shorter and more slender than other species of crows. The Common Mynas were captured using a mist net around the Universiti Sains Malaysia (USM), Pulau Pinang campus. The House Crows were obtained from the local municipal authority, Taman Tun Sardon, Pulau Pinang.

Our experiments were conducted from April 2012 to June 2012 at the School of Biological Sciences (5°21'N, 100°18'E), USM. A total of six Common Myna and six House Crows were used for the experiments. All of the birds were kept in a custom-made cage with a floor area of 12.6 m^2. The cage was divided into three sections with the middle compartment designated as the experimental area and the other two compartments as holding cages. The cage was cleaned regularly to maintain a healthy and clean environment for the birds. Both species were fed with similar food and clean water once a day. Outside of the experimental sessions, the birds were fed with white bread, fruits, rice and mealworms. Experimental trials were conducted three times per week on Mondays, Wednesdays and Fridays and lasted from 1600 to 1800. A one-day gap between experiments was allowed to prevent stress on the birds.

We evaluated the birds' numerical competency using choice-test experiments with mealworms. Each trial was recorded using a Sony Legria video recorder and followed the protocol described by Hunt *et al.* (2008). For each trial, only one bird was used at a time and each experiment was repeated three times. At the start of the experiment, a bird was released from the holding cage into the experimental cage. The researcher then showed the mealworms to the bird for five seconds before depositing the mealworms into the container cup. The mealworms were placed in two opaque white cup containers measuring 70 x 50 x 97 (mm). Both cups were placed 50 cm apart on a plastic black board. This process was repeated several times to acclimatise the birds to the food dropping process and to the researcher's presence. The trial was then recorded when the bird was calm and attentive. Two researchers conducted each trial (one to record the trial and the other to put the mealworms in the container) to reduce recognition bias from the birds. The researchers wore a breathing mask, white gloves and a white lab coat, both for the safety of the researcher and to reduce any facial recognition bias from the birds. We then proceeded to test different proportions of food items in the container cups. Seven food item combinations were presented to all 12 birds: 1 versus 3, 1 versus 4, 2 versus 5, 3 versus 7, 5 versus 8, 6 versus 9, and 8 versus 10. These combinations were tested in a random order to control for observational learning behaviour. The left or right orientation of the different number combinations were also randomised to prevent preference bias and to control for observational learning (Hunt *et al*. 2008).

Initially, most of the birds would perch at the highest position in the experiment cage and observe the researcher's actions. During the early stages of the trials, both House Crows and Common Myna needed approximately five minutes to choose the food item. However, after several repetitions of these trials, the birds learned to choose a food item within one minute after the trial began. Occasionally, the birds would continue searching for food items in the other cup even after the first selection. House crows produced noisy vocalisation and flew aggressively during the trials, and similar to Medina *et al.* (2011), they exhibited an agonistic response for the duration of the experiment. However they managed to count or distinguish the number of mealworms in the paper cup. Comparatively, although the Common Myna did produce noisy vocalisations, they were quite passive and calm during the trials. The experimental observations were conducted within a five minutes time frame. If the bird chose the food item with the highest number, it was considered to have made the "correct choice". The selection of the food item with the lowest number would be considered the "wrong choice". If the bird did not show any reaction or did not choose any food item after five minutes, the trial was considered a failure and excluded from the analysis. The results were analysed via a binomial test using JMP 10 software (SAS, Petaling Jaya, Kuala Lumpur).

RESULTS AND DISCUSSION

When testing the House Crows, we found that only one (one versus four) out of the seven different food proportion combinations was significantly different, where the birds selected the cup with more mealworms at frequencies above random chance (p = 0.041) (Fig. 1). Overall, the House Crows made successful choices, as shown in Figure 2. These data suggest that the crows are capable of discriminating larger versus smaller numbers because the number of successes exceeded the number of failures (133 successes over 108 failures).

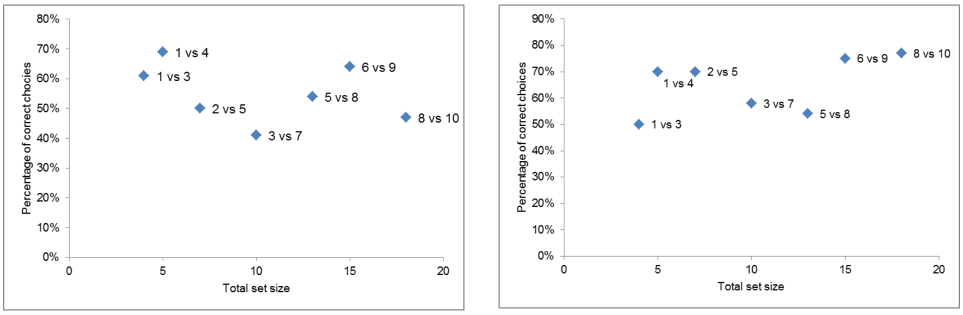
Our results showed that the Common Myna has a better numerical competency than the House Crow. In four out of the seven food proportion combinations (1 versus 4, 2 versus 5, 6 versus 9 and 8 versus 10), the Common Myna made successful choices at frequencies above random chance (Fig. 1). We found that the Common Myna can easily discriminate a larger quantity over a smaller quantity because the number of successful choices exceeded the number of failures (161 successes over 86 failures) (Fig. 2).

Hunt *et al.* (2008) stated that most animals can differentiate small quantities, but after training (learning, observing and experiencing), animals are also able to distinguish larger quantities. For example, after extensive training, primates have the ability to discriminate more than four items (Beran 2004). The exact numerosity judgment, which is limited to four countable items, has led to the suggestion that different mechanisms may be responsible for the representation of large versus small number sets (Feigenson *et al*. 2004). In Yellow Mealworm beetle (*Tenebrio molitor*) males (Carazo *et al*. 2009), the numerical competence training involved sequentially presenting items but had a set size limit of four items. Similar numerical competency has also been found in Rhesus macaque (*Macaca mulatta*) (Hauser *et al*. 2000).

Even though the House Crows only chose one food proportion combination at a rate above random chance, the House Crows often chose the larger of two quantities (133 successes over 108 failures) (Fig. 2). This is similar to the studies by Brannon and Terrace (2000) and by Gallistel and Gelman (2000) that state that exactness in numerical judgments will decrease with increasing magnitude. In our first trial (using a food combination of one versus three items), the crows made more successful choices but at a rate below chance. Unfamiliarity and lack of learning experience, however, might have affected these early trials and may be the reason that the proportion of successful to failed choices was not significant. According to Werdenich and Huber (2006), this could be attributed to the fear of trying something new (neophobia) in the crows. Our results show that crows did not process information about quantity in an efficient manner and perhaps chose the food item randomly. The House Crows might have developed a preferential selection based upon the orientation of the food cups the first time they encountered the larger food portion. A similar result was observed in a study by Willson and Comet (1993) using adult Northwestern Crows (*Corvus caurinus*), where the birds exhibited individual preferences for sugar and lipid content and the colour of the food. Another possibility is that the crows remembered the first cup they chose and continued to choose the same cup because of observational spatial memory (Emery & Clayton 2004). The crows also have a tendency to select larger food items but to avoid extra energy and greater handling cost, they may strategically choose the cup with the smaller portion (Hunt *et al*. 2008). We also speculate that the crows could have simply chosen a cup based upon the fact that they knew both cups contained food and it is more beneficial to select the cup nearest to their perching position.

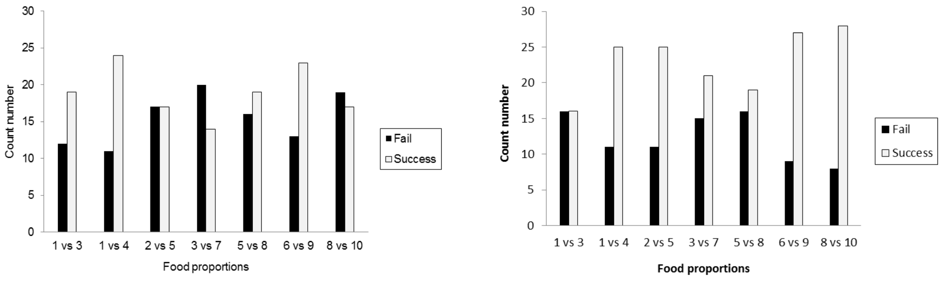
Comparatively, the Common Myna had an impressive number of successful choices – 161 successes and 86 failures (Fig. 2). This indicates Weber’s Law does not apply for the Common Myna. Similar to the House Crows, unfamiliarity and lack of experience could have affected the earliest test (one versus three). However, unlike the House Crows, the Common Myna managed to adapt and learn within a short period of time. The last two proportions tested (6 versus 9 and 8 versus 10) had a significantly higher success count compared to all the other food item proportions. We speculate that this was due to learning between trials. There are other aspects of learning besides habituation and operant conditioning, which are also considered to be part of instrumental (or observational) learning. This instrumental learning was made possible because the experimental test area and the confinement area for the myna was located next to each other. We observed that the Common Myna had the tendency to perform a successful choice after observing another individual bird select a larger over a smaller quantity of mealworms. A similar situation has been previously observed in ducks, where it was shown that they could learn their tasks by observation (Klopfer 1957). The improvement of the Common Mynas' numerical capacity could also be attributed to the fact that birds can be trained naturally and have the tendency to develop more advanced numerical abilities over an extended period of time (Hunt *et al*. 2008). Another possible explanation for the excellent performance of the Common Myna is that extensive experience enhances the formation of analogue numerical representations (Tomonaga 2008).

Even though the House Crow is an invasive species in Malaysia (Nyari *et al*. 2006), both House Crow and Common Myna species are commonly found in Malaysia and especially in Pulau Pinang. Both species of birds can successfully adapt to any environment, including urban developments. Both species are omnivorous where they feed mainly on insects, fruits and grains. Regularly they have been seen to feed on refuse around human habitation too. The ability of these two species to adapt to a new environment as well as compete with each other for resources is an open debate. Our results show that the Common Myna may be more intelligent than the House Crow in terms of counting ability. The Common Myna made 161 successful selections, while the House Crow only made 133 successful selections (Fig. 2). Although both species of birds selected more food items, the House Crow made wrong choices more often (108 failures) than the Common Myna (86 failures).



(a) (b)

Figure 1: Results for (a) House Crows and (b) Common Myna where the total of number of food items used in each trial is on the *x*-axis, and the percentage of birds choosing the greater number of food items is on the *y*-axis.



(a) (b)

Figure 2: The number of successes and failures for each food item combination for (a) House Crows and (b) Common Myna.

CONCLUSION

From our observation, House Crows are capable of discriminating a large number of items from a smaller number. Although House Crows were long known as intelligent birds, our results indicate that the numerical learning capacity of the House Crows might be lacking. These results also suggest that the House Crows' total limit for making numerical discriminations is less than four. However, further studies on the numerical competency of House Crows are needed. Our results provide the field with a better understanding of how animals solve mathematical problems. Based on our results, we suggest that the Common Myna uses memory cognition when counting, rather than subitising. This study also provides evidence that the numerical competency of these birds can be improved by observational learning. Future studies should therefore use different procedures, such as operant conditioning, involving both active and passive reinforcement.

ACKNOWLEDGEMENT

The authors thank all the staff from the School of Biological Sciences, USM for their help during the sampling session. This project was funded by USM Short Term Grant 304/PBIOLOGI/6311071.

REFERENCES

Addessi E, Crescimbene L and Visalberghi E. (2008). Food and token quantity discrimination in capuchin monkeys (*Cebus apella*). *Animal Cognition* 11(2): 275–282.

Balakrishnan J D and Ashby F. (1992). Subitizing: Magical numbers or mere superstition? *Psychological Research* 54(2): 80–90.

Beran M J. (2004). Chimpanzees (*Pan troglodytes*) respond to nonvisible sets after one-by-one addition and removal of items. *Journal of Comparative Psychology* 118(1): 25–36.

Brannon E and Terrace H S. (2000). Representation of the numerosities 1–9 by rhesus macaques (*Macaca mulatta*). *Journal of Experimental Psychology: Animal Behavior Processes* 26(1): 31–49.

Bugnyar T, Stoewe M and Heinrich B. (2007). The otogeny of caching in ravens, *Corvus corax*. *Animal Behaviour* 74(4): 757–767.

Carazo P, Font E, Forteza-Behrendt E and Desfilis E. (2009). Quantity discrimination in *Tenebrio molitor*: Evidence of numerosity discrimination in an invertebrate? *Animal Cognition* 12(3): 463–470.

Dacke M and Srinivasan M V. (2008). Evidence for counting in insects. *Animal Cognition* 11(4): 683–689.

Emery N J and Clayton N S. (2004). The mentality of crows: Convergent evolution of intelligence in corvids and apes. *Science* 306(5703): 1903–1907.

Egeth H E, Leonard C J and Palomeras M. (2008). The role of attention in subitizing: Is the magical number 1? *Visual Cognition* 16(4): 463–473.

Feigenson L, Dehaene S and Spelke E. (2004). Core systems of number. *Trends in Cognitive Sciences* 8(7): 307–314.

Gallistel C R and Gelman R. (2000). Non-verbal numerical cognition: From reals to integers. *Trends in Cognitive Sciences* 4(2): 59–65.

Hauser M D, Carey S and Hauser L B. (2000). Spontaneous number representation in semi-free ranging rhesus monkeys. *Proceedings of the Royal Society B: Biological Sciences* 267(1445): 829–833.

Heptonstall R A E. (2010). The distribution and abundance of Myna birds (*Acridotheres tristis*) and Rimatara Lorikeets (*Vini kuhlii*) on Atiu, Cook Islands. MSc. diss., UK: Leeds University.

Hunt S, Low J and Burns K C. (2008). Adaptive numerical competency in a food-hoarding songbird. *Proceedings of the Royal Society B: Biological Sciences* 275(1649): 2373–2379.

Kak S. (2000). Grading intelligence in machines: Lessons from animal intelligence. In A Meystel and E R Messina (eds.). *Measuring the performance and intelligence systems. Proceedings of the 2000 PerMIS Workshop.* Gaithersburg, MD, August 14–16 2000. Washington, DC: The National Institute of Standards and Technology (NIST), 331–334.

Katz M A. (2007). *Numerical competence and the format of mental representation.* PhD diss., University of Pennsylvania.

Kaufman E L, Lord M W, Reese W and Volkman J. (1949). The discrimination of visual number. *The American Journal of Psychology* 62(4): 498–525.

Kenward B, Rutz C, Weir A A S and Kacelnik A. (2006). Development of tool use in New Caledonian crows: Inherited action patterns and social influences. *Animal Behaviour* 72(6): 1329–1343.

Klopfer P H. (1957). An experiment on empathetic learning in ducks. *American Naturalist* 91(856): 61–63.

Medina F S, Taylor A H, Hunt G R and Gray R D. (2011). New Caledonian crows' responses to mirrors. *Animal Behaviour* 82(5): 981–993.

Nyari A, Ryall C and Peterson A T. (2006). Global invasive potential of the house crow, *Corvus splendens* based on ecological niche modelling. *Journal of Avian Biology* 37(4): 306–311.

Piazza M, Mechelli A, Butterworth B and Price C J. (2002). Are subitizing and counting implemented as separate or functionally overlapping process? *NeuroImage* 15(2): 435–446.

Reznikova Z and Ryabko B. (2011). Numerical competence in animals, with an insight from ants. *Behaviour* 148(4): 405–434.

Shaw R C and Clayton N S. (2012). Eurasian jays, *Garrulus glandarius* flexibly switch caching and pilfering tactics in response to social context. *Animal Behavior* 84(5): 1191–1200.

Scarf D, Hayne H and Colombo M. (2011). Pigeons on par with primates in numerical competence. *Science* 334(6063): 1664.

Tennesen M. (2009). Animals by the numbers. *Scientific American* 301(3): 23–24.

Tomonaga M. (2008). Relative numerosity discrimination by chimpanzees (*Pan troglodytes*): Evidence for approximate numerical representations. *Animal Cognition* 11(1): 43–57.

von Bayern A M P and Emery J N. (2009). Jackdaws respond to human attentional states and communicative cues in different contexts. *Biology* 19(7): 602–606.

von Bayern A M P, Heathcote R J P, Rutz C and Kacelnik A. (2009). The role of experience in problem solving and innovative tool use in crows. *Current Biology* 19(22): 1965–1968.

Weir A A S, Chappell J and Kacelnik A. (2002). Shaping of hooks in New Caledonian Crows. *Science* 297(5583): 981.

Werdenich D and Huber L. (2006). A case of quick problem solving in birds: String pulling in keas, *Nestor notabilis*. *Animal Behavior* 71(4): 855–863.

Willson M F and Comet T A. (1993). Food choices by Northwestern Crows: Experiments with captive, free-ranging and hand raised birds. *The Condor* 95(3): 596–615.

Yosef R, Zvuloni A and Yosef-Sukenik N. (2012). House Crow (*Corvus splendens*) attempt to cooperatively kleptoparasitize Western Osprey (*Pandion haliaetus*). *The Wilson Journal of Ornithology* 124(2): 406–408.